Electrochemical and Metallurgical Industry

VOL. VI. NEW YORK, JULY, 1908. NO. 7.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the

ELECTROCHEMICAL PUBLISHING COMPANY

239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....*President*

E. F. ROEBER, PH. D.....*Editor and Secretary*

C. E. WHITTLESEY.....*Treasurer*

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

Copyrighted, 1908, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, JULY, 1908.

CONTENTS.

EDITORIAL 267
The American Institute of Chemical Engineers and The Mining and Metallurgical Society 267
Hard Spots in Steel Castings 267
Copper Refining as an Engineering Proposition 268
Use and Prices of Steel 268
The Iron and Steel Market 270
Notes on the Structure of a Brittle Sheet of a Very Low Carbon Steel. By A. Sauveur 271
American Institute of Chemical Engineers 272
CORRESPONDENCE .....
Boiling Point of Zinc. By W. McA. Johnson 272
Diaphragms. By A. G. Betts 272
A Laboratory Experiment to Illustrate the Changes in Magnetic properties Occurring at the Thermal Critical Points in Steel. By H. M. Boylston 273
Industrial Electrochemistry in Russia. By P. N. Piltschikoff 274
METALLURGICAL CALCULATIONS (Condensation of Zinc and Mercury Vapor). By J. W. Richards 275
Silver Refinery of the New Addition to the Raritan Copper Works. By Frank D. Easterbrooks 277
Hard Spots in Steel Castings. By Arthur P. Scott 281
Separating Appliances—II. By Oskar Nagel 287
Annual Meeting of the Iron and Steel Institute (with abstracts of papers by T. J. R. Carulla, A. Lamberton, T. E. Stanton, J. E. York, B. Igewsky and E. F. Law) 290
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN 297
SYNOPSIS OF PERIODICAL LITERATURE 299
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 300
RECENT METALLURGICAL PATENTS 301
Blast Separator, Gas Scrubber and Dust Collector 301
Missouri River Development 302
Columbia University 303
A New Manganese-Silicon Alloy 303
Water Sterilization for House Use 304
Equipment of a Large Zinc Oxide Plant 305
Notes 305
DIGEST OF U. S. PATENTS (Electric Furnaces) 306
NEW BOOKS 307
BOOK REVIEWS .....
A. G. Betts' Lead Refining by Electrolysis 308
H. E. Patten and T. E. Gallagher's Absorption of Vapors and Gases by Soils 308
A. F. Holleman's Text Book of Organic Chemistry 308
Journal American Peat Society, Vol. 1, No. 1 308

The American Institute of Chemical Engineers and the Mining and Metallurgical Society of America.

The formation of the Mining and Metallurgical Society of America and of the American Institute of Chemical Engineers has added two new professional organizations to the list of national engineering societies of this country. Both are intended to be strictly professional societies, the membership being strictly limited to mining and metallurgical engineers and to chemical engineers respectively. The Mining and Metallurgical Society intends to enter into the following principal fields of activity: the establishment of local sections, to promote good fellowship and exchange of views; the determination of standards in engineering practice; the discussion of questions relating to professional practice and ethics; and the discussion of questions of public policy in which the profession of mining engineering is directly concerned. The American Institute of Chemical Engineers—the inaugural meeting of which is reported on another page of this issue—intends to stand for chemical technology or chemical engineering rather than for pure chemistry. Its formation is the outgrowth of the sentiment which has been so strongly manifest in recent years, that the chemical engineer is not recognized either by his brother engineers or by the public at large as fully as the importance of chemical engineering work deserves.

* * *

In view of the admirable work which the American Institute of Mining Engineers and the American Chemical Society have been doing in the past, objections to the formation of the new societies have been repeatedly and honestly put forward in recent months, but such objections are now useless and out of order. The Mining and Metallurgical Society of America and the American Institute of Chemical Engineers have been formed; they have been formed by enthusiastic professional men to further the best interests of their profession. In recording this fact, we express the sincere hope that the new societies will fulfill all the useful purposes which animated their founders and incited them to the step they have taken.

Hard Spots in Steel Castings.

It is with particular pleasure that we call attention to the article of Mr. A. P. Scott on hard spots in steel castings, the first part of which appears in this issue. The subject is interesting enough in itself and for this reason Mr. Scott's exceedingly careful analysis of the causes of the particular hard spot discussed in his article is very valuable. But what makes Mr. Scott's paper so peculiarly attractive is the able manner in which modern methods of experimental research are made use of and the broad view which the author takes in extending the results of the experiments of his special case to general conclusions on diffusion phenomena in solid solutions. We intend to comment on Mr. Scott's paper at greater length after publication of the concluding instalment in our next issue.

Copper Refining as an Engineering Proposition.

Mr. F. D. Easterbrooks' article in this issue, on the silver refinery of the new addition to the Raritan Copper Works, completes his description of this highly interesting plant, which is certainly one of the finest examples of modern copper refining practice and is evidence of a very high order of engineering ability and technical knowledge of its designers. Mr. Easterbrooks' serial consisted logically of three articles. In our May issue the power plant was described. Cheap power is the necessary foundation of the commercial success of copper refining and of any electrolytic industry in general, and the new Raritan power plant is an interesting example of the possibility of generating power cheaply even with steam, the ideal condition of a 100 per cent load factor being, of course, the principal factor in favor of low cost. In our June issue the copper refinery proper was described. The primary object of a copper refinery is, of course, to refine copper, and it is perfectly true, as has been said, that the advent of the dynamo made electrolytic copper at once possible and necessary. The electrical industry needs pure copper and the cheapest way of purifying copper is by electrolytic refining. Electrolytic copper refining would have become a commercial necessity, even if there had not been the possibility of recovering thereby at low cost the precious metal impurities. As the situation now is, the easy recovery of the gold and silver forms one of the strongest points of electrolytic copper refining, and Mr. Easterbrooks' serial is thus logically concluded by the description of the silver refinery.

* * *

The refining of silver is another example of the universal rule, that for the sake of continuity of operation every electrolytic process requires relatively pure starting materials; or, in other words, electrolytic methods are chiefly applicable to the last refining step of a process only. In the recovery of silver and gold from the slimes of the copper refinery, electrolysis is employed only in the final parting of the bullion, which is preceded by the slime-room treatment, where the copper is extracted and the slimes pressed and washed, and by the treatment in the furnace room, where the slimes are melted and blown to bullion. With reference to the electrolytic separation, the Balbach-Thum process, used at the Raritan works, will be found interesting in comparison with other methods. Of particular interest are Mr. Easterbrooks' notes on the loss of silver in melting with open furnaces, since practice confirms here the consequences of theory. Nothing has ever been published to our knowledge on the actual losses of silver in practice, and we may express the hope that reliable information on this point may become available, since the matter is exceedingly interesting and important. The Raritan practice of recovering the values mechanically carried into the flues, by means of a combination of settler and water scrubber, should attract the attention of all who are interested in the smelter fume problem for the double purpose of making the fumes harmless and recovering any values contained in the same.

* * *

There is one fundamental fact that is thoroughly emphasized by this account of the new plant of the Raritan Copper Works, that is the difference between the ways of carrying out an electrochemical process in the laboratory and on a large scale in practice. It is hardly possible to find a simpler electrolytic process for laboratory work than copper refining, while a great many complications arise on a large scale. Factors which are plainly negligible in the laboratory become of importance on a large scale. There is, of course, no real difference between the reactions themselves on a small and on a large scale. The solution of the problems which has been found in the laboratory, can be and must be usefully employed on a large scale. But new additional problems arise which must be solved for successful large-scale operation, and these new problems are of an essentially different character. After a process has been worked out in the laboratory, it becomes an engineering proposition—engineering problems arise which have nothing to do with the electrochemical reaction, but rather with the general arrangement of the works and of the process so as to make it a good paying proposition—in short, problems of organization. The solution of such problems as the organization of the purchasing department, for instance, have a very decisive influence on the financial results. Naturally this, like various other problems of organization, are not dealt with in Mr. Easterbrooks' serial, which is restricted to a description of the metallurgical works, chiefly from a constructional point of view. But the lay-out of the works as a whole and the arrangement of the details as well, as described in Mr. Easterbrooks' articles, show that a master mind was responsible for the design. Under such circumstances it is specially gratifying to note that in this wonderfully arranged organization the research laboratory was not forgotten—a small detail perhaps in the whole organization, but one which indicates the farsighted and progressive spirit which is characteristic of modern metallurgical engineering.

Price and Uses of Steel.

In June occurred the first clear break from the level of finished steel prices which had been artificially held over from the period of intense activity and heavy demand that came to an end very abruptly early in the fourth quarter of last year. Formal reductions of $4 a ton were made in merchant steel pipe, bars, hoops, bands and small structural shapes, and of $2 a ton in wire products, plates and shapes. The eagerness with which the steel manufacturers joined in a movement to maintain former prices when demand slumped, indicates that the price movement of the future will not be subject to the passing whims of individuals anxious to maintain a competitive position irrespective of consequences. It will rather be governed by the general fundamental conditions which surround the industry, to which respect must be yielded however strong is the sentiment among manufacturers for co-operation in the regulation and maintenance of prices. The price reductions just made were in line with these general conditions, whatever may have been the proximate causes. The general fundamental conditions to which we refer are the amount of iron ore in the ground awaiting utilization, the capacity in existence for converting it into iron and steel, and the store of iron and steel now in existence and in actual employment. It has already been pointed out in these columns that we made more pig iron in the United States in the past ten years than we had made in all the previous years, and that the major part of the iron

thus made survives as a store to be reworked at intervals and to be added to as our needs may indicate, having full reference to the actual cost of making such additions.

* * *

This view of the matter is not as common as it should be. There was recently held at the White House a conference on the conservation of our natural resources, which was attended by the governors of 44 States and by a number of other distinguished men. Reference was made to the loss which our national wealth undergoes through erosion and the carrying to the ocean of enormous quantities of fertile soil every year; to the devastation of our forests; to the waste in coal-mining, and to the rapidity with which the rate of mining iron ore has been increasing. The mining of iron ore, as a depletion of our national resources, was spoken of in the same breath as the waste in coal-mining, the erosion of the soil and the depletion of the forests, just as if to mine a ton of iron ore and convert it into steel was to wipe it out of existence, or lose it, as a ton of soil is lost if it is carried into the ocean, a ton of coal is lost if it is burned, or a tree is lost if it is cut up and exposed to the elements and bacteria without a new tree being grown in its place. It was a loose way of thinking and quite unworthy of the distinguished talent which was gathered at the White House Conference.

* * *

One of the most distinguished speakers at the conference, Mr. Andrew Carnegie, who is as much entitled to his little joke as the next man, presented his joke, but failed to arouse the risibilities of his audience. He spoke feelingly of the rapidity with which we have been "exhausting" our stores of iron ore and coal, and urged that we should use every means to save our iron ore, by turning to other materials, and in addition by turning from railroad to water transportation, as requiring less steel. By using less iron ore the coal required to smelt and convert it into finished steel would also be conserved. His statistics of our resources were 10,000,000,000 tons of iron ore and 2,500,000,000,000 tons of coal. The point to Mr. Carnegie's joke was that it requires less than a ton of coal to smelt a ton of iron ore and convert the pig iron into finished steel, so that to put all our iron ore into use as steel would require less than two-fifths of one per cent. of all our coal. He should have had a friend in the audience to explain the point and start the laughter.

* * *

In the ten years, 1898 to 1907 inclusive, there was made in the United States about 181,500,000 tons of pig iron; in all the previous history of the industry there was made a trifle less than 170,000,000 tons, making a total production, to the beginning of this year, of about 350,000,000 tons. That is four gross tons per capita of our present population. Is that iron lost? The most cursory inventory will find a great part of it, and it is fairly safe to assume that three tons per capita have survived and are in actual employment to-day. The visible supply of iron ore in the United States is sufficient to make 5,000,000,000 tons of pig iron, or 57 tons per capita. That would give us 60 tons per capita instead of three tons. How long will it be until our requirements increase twenty fold? The visible supply of iron ore, however, has been increasing so rapidly that there is no prospect of the rate of smelting overtaking the rate of addition. These additions are made in two ways, by the discovery of new material and by the discovery of new processes, whereby what is the worthless material of one period becomes the commercial iron ore of the next period. The electric process, for instance, as thus far developed, adds enormously to the resources, although the addition is so new that the material which it can attack has not yet been added to the estimates of our iron ore reserves.

* * *

Steel is competitive with wood in nearly all uses to which wood is put. If the White House Conference had declared that the freer use of our iron ore reserves constituted the most practical means of saving our timber it would have made a sensible declaration. Instead of this, its deliberations tended to spread the impression that iron ore should be saved as coal, timber and fertile soil should be saved. If the permanent organization which is to be formed as an outgrowth of the conference wishes to do practical work, it is hard to see how it can do better than to endeavor by all possible means to increase the use of steel and to encourage the development of processes looking to the making of steel more cheaply, and to the use of material not now regarded as commercial iron ore. It certainly should be its attitude that steel should be sold at the lowest possible prices.

* * *

As we have already said, the reductions just made in steel prices are in line with the needs of the case. The industry itself needs all the help which can thus be afforded, because the enormous addition made to our store of iron and steel in actual employment during the past ten years, more than doubling it indeed, raises the serious question whether the present capacity can find full employment except by a fresh spreading in the uses for steel, through the medium of lower prices. Assuming our present store of iron and steel as the equivalent of between 250,000,000 and 300,000,000 tons of pig iron, the present capacity, with additions now in course of erection, making a total of some 31,500,000 tons of annual capacity, can double that store in eight or ten years. New uses will find themselves, if the price is made right. The steel railroad tie constitutes one instance. The principal objection which has been urged against it is that it is too light. Nothing made it too light except the high price per pound at which it was desired to sell it. Taking the form of steel tie which has been most used, it may be said that if it were sold at the same price per pound that steel rails brought at one time, almost double the material could be put into it, at the same price per tie that has been asked. Then it certainly would not be too light. If the tie were increased in weight by two-thirds, it would require about 100,000,000 tons of steel to lay the present mileage of track with it.

* * *

The trend of events is clearly in the direction of finding a much larger use for steel through the medium of prices more in keeping with what the steel industry has shown it can do, whereby it will again find full employment, and whereby the depletion of our forests can be retarded, if not absolutely arrested. The last thing the conservators of our national resources need fear is the exhaustion of our iron ore reserves. Their work should lie in exactly the opposite direction to encourage the use of this iron ore.

The Iron and Steel Market.

June has brought some interesting developments in the iron and steel trade. The Lake Superior ore interests put in force a 50-cent concession from the 1907 ore prices, which they had previously been lined up to maintain for the present season, while on June 1 and June 9 reductions were made in all important finished steel products except sheets and tin plates, which were reduced January 6, and standard rails. In this latter branch the question is not one of the base price, but of the charging of an extra for the new specifications calling for an improved rail. To renounce the demand for extras would be equivalent to a reduction, and some move in this direction will probably be made.

ORE PRICES.

The new schedule on Lake Superior ores is as follows, f. o. b. Lake Erie docks:

Old range Bessemer	$4.50
Mesabi Bessemer	4.25
Old range non-Bessemer	3.70
Mesabi non-Bessemer	3.50

The base analyses are as follows: Bessemer, 55 per cent iron content, natural state, with 10 per cent moisture and .045 per cent phosphorus, when dried at 212°; non-Bessemer, 51.50 per cent iron content, natural state, with 12 per cent moisture. The new basis was adopted for the season of 1907, the previous guarantees having for many years been as follows: Bessemer, 63 per cent iron when dried at 212°, equivalent to 56.70 per cent iron in the natural state; non-Bessemer, 60 per cent iron when dried at 212°, equivalent to 52.80 per cent in the natural state. The change of base was in itself equivalent to an advance in price, and the retention of the same phosphorus content, with the reduced iron basis, was equivalent to a slight loosening in the phosphorus restriction, a point which does not appear to have been commented on, although it is of some consequence considering the increased difficulty in securing ores suitable for the manufacture of Bessemer pig iron. During the high pressure in 1906 and 1907 a great deal of Bessemer pig iron and Bessemer steel was made which ran closer to .12 per cent phosphoras than to .10 per cent, that being the recognized outside limit.

Subject to the base guarantees ruling in the different seasons, Lake Superior ore prices have been as follows, prices in 1898 being given as they showed the lowest average on record:

	Old Range Bessemer.	Mesabi Bessemer.	Old Range Non-Bessemer.	Mesabi Non-Bessemer.
1898	$2.75	$2.20	$1.80	$1.75
1905	3.75	3.50	3.20	3.00
1906	4.25	4.00	3.70	3.50
1907	5.00	4.75	4.20	4.00
1908	4.50	4.25	3.70	3.50

Scarcely any mining was done during the winter and spring, and mining has been relatively light to date. The season movement promises to run 20,000,000 tons or less, or less than half the 1907 record. With so long a period of quiescence, monthly shipments toward the close of the season promise to be quite heavy.

FINISHED STEEL PRICES.

The reductions in official prices of finished steel products have been as follows:

June 1. Steel-bars, bands, hoops and light structural shapes reduced $4 a net ton to 1.40c, base, half extras on the bar card, for merchant steel bars and bands; to 1.50c, base, half extras on the bar card, for small structural shapes, these being angles, channels and tees under 3-inch, and angles 3 x 3 less than ¼ inch thick, and to 1.80c, base, full extras on the hoop card, for hoops.

June 9. Merchant steel pipe reduced two points or about $4 a net ton, to 75 off list for "jobbers' carloads," making the inside price 76 and 5 off list, on sizes ¾ to 6-inch inclusive, the net price on such sizes being therefore about 2.28c a pound.

Plates reduced $2 a net ton, to 1.60c, base, for tank quality, with extras for widths over 100 inches, thicknesses under ¼ inch, and quality.

Structural shapes reduced $2 a net ton to 1.60c, base, this covering angles and tees and beams and channels 15-inch and under; tees, 1.65c, and beams and channels over 15-inch, 1.70c.

Wire products reduced $2 a net ton, to 1.80c, base, for plain wire, $1.95, base, for wire nails, and 2.40c, base, for galvanized barb wire.

BILLET AND SHEET BAR PRICES.

The official prices on billets and sheet bars were reduced June 9 by $2 a net ton, making the new prices as follows:

Billets, $25, delivered Pittsburg; delivered prices, $25, Pittsburg, plus the following additions: to points taking less than 50 cents freight from Pittsburg, the full freight; to points taking 50 cents to $1 freight, 50 cents additional; to points taking $1 to $3 freight, one-half the freight additional; to points taking more than $3 freight, the full freight additional, less $1.50.

Sheet bars, $27.50, delivered Pittsburg; delivered prices, $27 f. o. b., Pittsburg, plus the same additions as in the case of billets, except that Canton, Ohio, and Buffalo, N. Y., are $27.50 delivered.

The old sheet bar prices were quite well observed, and the new prices are being equally well observed. The old billet price, on the other hand, was largely nominal, as some mills were making cut prices. Besides this, the bulk of the movement was under scale contracts, based upon the Bessemer pig iron average, and the decline in Bessemer pig iron had brought the adjustment prices on such contracts down to between $24 and $25.

SHEETS AND TIN PLATES.

The leading interest in sheets and tin plates and the independent manufacturers held a very well attended meeting in Pittsburg, June 12, and decided to attempt to maintain former prices, despite the $2 reduction in sheet bars, whereas declines in sheet bars have usually been accompanied by similar reductions in the finished products. Reports of a number of cases of shading in sheets were reported to the meeting, but not a single case was reported of shading in tin plates, and as tin plate mills were running to substantially full capacity, while the sheet mills were running to less than 40 per cent of normal, it was decided not to disturb the situation at this time. Tin plate is $3.70, black sheets 2.50c, and galvanized sheets 3.55c, less 5 cents per 100 lb. rebate.

THE MARKET MOVEMENT.

At the time of the steel bar reduction about 100,000 tons of contract business was reinstated at the new price, specifications having been withheld, and heavier specifications are now expected on this business. At the same time fresh contracts for about 125,000 tons of bars were entered. This business was chiefly from wagon and agricultural implement makers, for their season July to June inclusive. Jobbers and other buyers were restricted to deliveries to October 1, at the reduced price.

Outside of the steel bar business new buying has been very light in finished steel products. Mill activity, as a whole, was slightly less in June than in May, continuing the progressive diminution which has been in progress since about April 1. Operations are expected to be very light in July.

The opinion is almost universally entertained among both sellers and buyers that there will be a marked increase in iron and steel activity after July, although in no quarter is it expected that the trade can reach its full measure of activity at any time this year, and serious doubts are entertained whether the full productive capacity can be engaged even next year, except at further reductions in finished steel prices.

PIG IRON.

The announcement of the reduction in Lake Superior ore prices has not adversely affected pig iron prices. The market

has been very quiet, but furnacemen, as a rule, are firm in their views. Foundry iron in the Chicago district is about 25 cents higher, and in Eastern Pennsylvania about 25 cents lower. In the Central West there was a good buying movement in basic pig iron about June 1, the American Steel Foundries taking 30,000 tons for Alliance, and 10,000 tons for St. Louis, the Allegheny Steel Company taking 7,000 tons, and the Page Woven Wire Fence Company making a sliding contract for three years, covering a total of about 50,000 tons. Basic pig advanced about 25 cents in consequence of this movement, and is now $15.25 to $15.50, valley furnace. Bessemer pig remains at $16, valley. Foundry iron in the valleys is firmer, at $14.60 to $15.

FIG. 1.—STEEL SHEET, HEATED TO 835° C. AND COOLED WITH FURNACE. MAGNIFIED 50 DIAMETERS.

FIG. 3.—MAGNIFIED 100 DIAMETERS.

An excellent movement occurred in Southern iron, at special prices, $11.50 Birmingham, and lower, and by the middle of the month the Southern market had firmed up to $12 to $12.50, Birmingham.

Since March pig iron production has been declining slowly but steadily. From the record rate of a trifle over 28,000,000 tons a year, reached in October, it declined to about 12,600,000 tons in January, then advanced to about 14,800,000 tons in March, declining to about 14,000,000 tons in June.

Note on the Structure of a Brittle Sheet of a Very Low Carbon Steel.

BY ALBERT SAUVEUR,
Professor of Metallurgy in Harvard University.

In the course of an examination of the structure of a brittle sheet of very low carbon steel, one of the treated samples was found to exhibit a structure so peculiar as to warrant, I think, the recording of it in these columns.

The brittle sheet referred to contained about 0.05 per cent of carbon, and the brittleness from which it suffered was undoubtedly of the kind described by Stead and must have been produced by a prolonged heating at a relatively low temperature, say between 600 and 700 degrees Centigrade. As an evidence of this, it will suffice to mention that fracture (by punching) always occurred at an angle of 45 deg. to the direction of rolling, which is the most marked characteristic of this peculiar brittleness.

FIG. 2.—MAGNIFIED 100 DIAMETERS.

A number of strips were cut from this sheet and subjected to different treatments. One of them was heated to 835 deg. C. in a muffle gas furnace and allowed to cool slowly with the furnace. The sample was then polished and etched with a solution of nitric acid in absolute alcohol, when the structure illustrated in Figs. 1, 2 and 3 was brought out.

It will be noted that many of the ferrite grains contain a number of thick bands which are always parallel in the same grain, but whose direction is generally different in different grains. It will also be noted that they come to an abrupt stop at the junction lines of the ferrite grains, and in no case is there a band to be found crossing the boundary line between adjacent grains. It is natural to infer that the direction of these bands very probably indicates also the orientation of the small cubic crystals of which each grain of ferrite is formed, for it is well known that the orientation of these small cubic crystals is the same in any one grain, but changes as we pass from one grain to the next. It might, therefore, reasonably be supposed that each band is composed of a string of these small crystals, differentiated from their neighbors by a more vigorous attack on the part of the acid of the etching solution. Assuming this interpretation to be correct, how shall we account for this arbitrary and selective action of the acid which picks out for its attack parallel strings of the small crystals while leaving the surrounding crystals practically unaffected?

Or, are these bands some of Ewing's slip bands? This seems hardly possible for slip bands to cover the entire area of the strained grains, while in the structure shown here each ferrite grain contains but a very few bands, in no case more than eight.

American Institute of Chemical Engineers.

The committee appointed at Atlantic City last June to consider the advisability of the formation of an American Institute of Chemical Engineers, decided that a mail vote would be the best method of determining the sentiment of American chemists toward the proposed new organization. This mail vote was decisive in showing a strong sentiment for the formation of the institute, and as a consequence a meeting was called for the purpose of organization.

This inaugural meeting was held in the Engineers' Club, Philadelphia, Pa., on June 22. It was called to order at 10.30 a. m. Dr. C. F. McKenna was made temporary chairman. He introduced Dr. Samuel P. Sadtler, who welcomed those in attendance to Philadelphia, and spoke of the chemical industries of Philadelphia, and of the field of the chemical engineer.

Dr. McKenna then delivered an address, in which he referred to the fact that the chemical engineer was not as fully recognized as the mechanical engineer or the civil engineer, and expressed the conviction that an American Institute of Chemical Engineers, with its membership restricted as to age and other qualifications (such as education and experience), would do much to better the existing conditions. Dr. Hunicke, of St. Louis, followed with an address in which he outlined his ideas of the chemical engineer and the scope and importance of his work.

In the afternoon session the committee on constitution reported a draft of the constitution, which defined the purposes of the institute, the proposed qualifications of the members, dues, etc. The yearly dues were fixed at $15, with no initiation fees at present, the age limit at 30 years, and 10 years' practical experience in chemical engineering (from which a different number of years are deducted for college and university degrees which the applicants may have obtained).

The committee on nominations presented the following names for the officers of the institute: President, Samuel P. Sadtler, Philadelphia; first vice-president, C. F. McKenna, New York; second vice-president, A. Hunicke, St. Louis; third vice-president, E. G. Acheson, Niagara Falls; treasurer, W. M. Booth, Syracuse; secretary, J. C. Olsen, Brooklyn; auditor, R. K. Meade, Nazareth, Pa.

The directors will be for one year: Ludwig Reuter, Berkeley, Cal.; Thorn Smith, Isabella, Tenn.; H. F. Brown, Wilmington, Del.; for two years: J. M. Camp, Duquesne, Pa.; C. A. Catlin, Providence, R. I.; Eugene Haanel, Ottawa, Canada; for three years: G. P. Adamson, Easton, Pa.; David Wesson, Wilmington, Del., and E. Gudeman, Chicago, Ill.

The report of the committee was accepted and the above gentlemen were declared the elected officers of the institute.

The evening was spent in a general discussion of the plans of the institute.

About 85 gentlemen have already joined the American Institute of Chemical Engineers, but a much larger number will probably apply for membership now after the institute has been actually formed.

CORRESPONDENCE.

Boiling Point of Zinc.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—Naturally I have read with interest the articles of Professor Richards on the Metallurgy of Zinc, now appearing in your journal.

I notice that he uses 930° C. for the boiling point of zinc at 760 mms. This figure was obtained by Violle in 1882 and is undoubtedly too high. As will be explained later, high figures are usually recorded because of peculiarities of the methods.

Ingalls, in his Metallurgy of Zinc, page 2, gives 920° C. as the "latest determination," but does not cite his reference.

I have determined the boiling point of zinc many times and have found values varying between 918° C. and 922° C. (at 29.7 inches of mercury the value is 919° C.), using in each case pyrometer and couple tested by the Reichsanstalt.

It is quite easy to get readings too high unless an apparatus of iron or Acheson graphite is used because the temperature gradient is large.

Another source of error is caused by the zinc vapor absorbing oxygen and forming ZnO, a solid. This causes more air to be sucked in because the pressure in the "tester" is thereby lessened. These phenomena can raise the observed boiling point as much as 100° C. or to 1020° C.

It can be prevented by using a very small hole for the "test-hole" and covering the zinc well with *granular* charcoal.

With these precautions, using an apparatus similar to that used in my work on the reduction temperature (see Am. Electrochemical Society's Transactions, April, 1904; also this journal, vol. II, p. 185, the apparatus being illustrated on p. 186), and by raising the temperature slowly not over 0.5° C. per minute, the upper and lower readings (i. e., the start of the zinc flame and its stopping after ebullition) should agree within two degrees, the mean of three determinations within 1° C.

At high pressures up to 60 lbs. per sq. in. absolute pressure, or 45 lbs. gauge, the readings are much less accurate. Probably an extreme error of 3 per cent is involved.

But with a strong steel apparatus, while working for the Lungwitz Reduction Co., we did obtain without much trouble satisfactory determination of the boiling temperature of zinc at 60 lbs. absolute, quite different from those calculated by Professor Richards. I hope to publish an account of this work some day in your journal.

Hartford, Conn. Woolsey McA. Johnson.

Diaphragms.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—Supplementing the article by Mr. F. B. Crocker in the April issue of Electrochemical and Metallurgical Industry, I believe an account of some of my work with diaphragms, already published elsewhere[1], however, will be found useful to chemists taking up this problem.

In the first place, one is quite safe in saying that asbestos is the best all-round material available for diaphragms. The main difficulty is to support the asbestos in the position it is to occupy. I have made successful diaphragms, by forcing with moderate pressure, wads of wet asbestos into ⅜-in. to 1-in. round holes bored into ⅝-in. to ¾-in. boards.

Another and probably better method is to place two or three thicknesses of asbestos paper between two perforated sheets of lead, wood or hard rubber, according to the solution to be withstood. The resistance of a diaphragm of this kind, made of 4-lb. lead, plentifully perforated with ⅜-in. holes, of course opposite each other in the two sheets, is practically negligible. In a sulphate solution of uniform temperature the lead is practically permanent, and does not act as a metallic conductor. It cannot, in fact, under usual conditions.

The best diaphragm I know of for ordinary weak acid solutions is made as follows: Sift powdered sulphur evenly over a ¼-in. asbestos "mill-board," and heat the sheet evenly an hour or so to just above the melting point of sulphur. Repeat the operation with the other side. It takes from ¼ to ¾ lb. of sulphur to the square foot of the mill board. This diaphragm is plastic when heated, and in solutions *does not soften at all.* It expands slightly though and should be kept in acid water two or three weeks before using in any kind of rigid construction. The resistance is somewhat higher than without the sulphur, but the diffusion is smaller.

Troy, N. Y. Anson G. Betts.

[1] Lead Refining by Electrolysis. By A. G. Betts (New York: John Wiley & Sons).

A Laboratory Experiment to Illustrate the Changes in Magnetic Properties Occurring at the Thermal Critical Points in Steel.

BY H. M. BOYLSTON.

The experiment described below is not of itself new, having been performed for several years in the Metallurgical Laboratory of Harvard University by students under the direction of Prof. Sauveur, but the results obtained in the past two years with an improved form of apparatus have been so satisfactory as to justify a brief description of the method and apparatus used. Two suggestions for the practical application of the principle involved are also briefly described at the end.

The Apparatus consists essentially of three parts; namely, an electromagnet, a support for the test-piece, and a Le Chatelier thermo-electric pyrometer.

The electromagnet, A, Fig. 1, is arranged vertically and consists of a large number of turns of fine insulated copper wire wound on a porcelain tube. This wire constitutes the exciting coil and is supplied with an electric current of the proper strength. Inside the fireproof tube is suspended a soft iron core, *d*, ⅝ inch in diameter and having its lower end ground smooth normal to the length of the core. The lower end of the core should extend down not more than three inches below the magnet coil in order that a fairly strong magnetic field may be maintained. The coil is also protected from the heat of the blast lamps used for heating the test-pieces by several gaskets, *w*, made of heavy asbestos board.

The support, B, Fig. 2, consists of two concentric porcelain tubes wedged tightly together and arranged so that the upper end of the outer tube projects about ¼ inch above the end of the inner tube. The upper end of both tubes is ground smooth normal to the length of the tubes. The internal diameter of the outer tube should be but very little larger than the diameter of the test-piece. The upper end of the outer tube thus serves as a protecting collar to the thermo-couple which would otherwise be subjected to the full heat of the blast lamps when the test-piece is raised by the magnet.

The magnet and the support are held in place on an ordinary ring-stand by means of burette clamps and rings.

A Le Chatelier thermo-couple, C, properly insulated, say by means of an ordinary clay pipe-stem, is suspended inside the porcelain support in such a position that the hot junction, *h*, reaches nearly to the top of the previously drilled test-piece, *s*, when the latter is not being attracted to the magnet. The pipe-stem has the additional advantage of serving to nearly close the support tube to currents of air which otherwise would rise through the tube and cool off the test-piece.

The portion of the thermo-couple which extends through the center of the test-piece is bare, the two wires being very close together but not touching. These wires act not only as a temperature indicator, but as a guide upon which the steel piece slides freely up and down when attracted or released by the magnet.

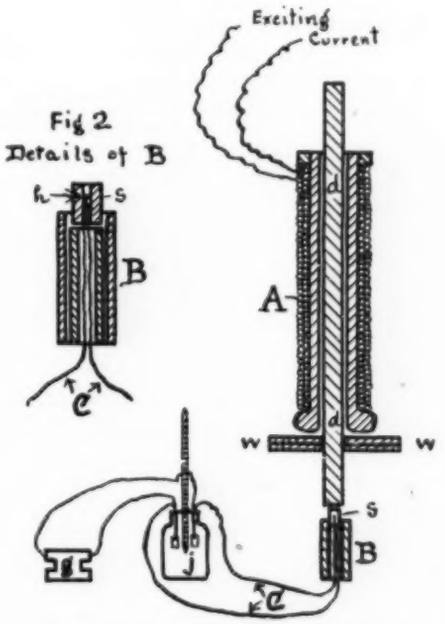
The cold ends of the thermo-couple are of course connected by means of copper leads in circuit with an ordinary pyrometric galvanometer, *g*. It has been found convenient to place the cold ends of the thermo-couple in an ordinary wide-mouth bottle, *j*, containing distilled water. A thermometer placed in the water will indicate the correction which must be added to the galvanometer reading to give the true temperature of the hot junction and therefore of the steel piece at any given moment. The needle of the galvanometer, of course, must be set at zero when connected with the couple in the air. This method of finding the correction has been found more convenient than the usual method of surrounding the cold junction with melting ice and is very nearly if not quite as accurate.

The Experiment.—A piece of ½-inch round steel about ¾ inch long is carefully drilled longitudinally through its center (conveniently with a ⅛-inch drill) and the ends of this test-piece are ground flat normal to its length.[1]

The drilled test-piece is now placed over the hot junction of the thermo-couple, resting upon the inner tube of the porcelain support so that the upper end of the steel remains not more than ⅛ inch below the lower end of the unmagnetized core. The hot junction of the thermo-couple is now inside the steel piece and a little below the top surface of that piece. The upper end of the outer porcelain tube acts as a protecting collar to the portion of the thermo-couple necessarily bared when the test-piece is lifted later by the magnet.

The exciting current of the electromagnet is now turned on and remains on during the entire experiment.

Loss of Magnetism on Heating at the Critical Range.—The test-piece, which is now clinging to the magnet, is heated



FIGS. 1 AND 2.—APPARATUS FOR ILLUSTRATING CHANGES.

gently and gradually[2] by means of two blast lamps, one on each side, and the temperature at which the piece ceases to be attracted to the magnet is carefully noted. It should be found to correspond closely to the thermal critical point (Ac_{3-2-1} in high-carbon steels, Ac_{3-2} in medium high-carbon steels, and Ac_2 in low-carbon steels) of the steel as determined in the usual way by means of heating and cooling curves.

This correspondence may be automatically checked by noting that very nearly at the instant the test-piece drops the galvanometer needle will stop short, or even reverse its direction of motion slightly in the case of high-carbon steels, indicating that the well-known absorption of heat or retardation of heating is taking place.

Recovery of Magnetism on Cooling at the Critical Range.—The heating should be continued until the piece is at white heat, when the lamps should be withdrawn, allowing the piece to cool in the close vicinity (within ⅛ inch) of the magnet. The temperature at which the piece is again attracted should

[1] The experiment is best carried out with high-carbon steels containing more than 0.80% of carbon as such steels have only one critical point, Ac_{3-2-1} (on heating) or Ar_{2-3-1} (on cooling), and that point is very marked, but the figures given in Table 1 show that steels with less carbon give good results, remembering that the critical points determined by this method would be Ac_{2-3} and Ar_{3-2} in medium carbon steels and Ac_2 and Ar_2 in low-carbon steels.

[2] The fact that the lower ¼ inch of the test piece is not heated as rapidly as the rest of the piece because of the porcelain collar surrounding it does not interfere with the measurement of the temperature at which the piece loses its magnetic properties for the hot junction is situated near the top of the ¾-inch long test-piece.

be carefully noted. It will be found to correspond closely to the critical point (Ar_{3-2-1}, Ar_{3-2} or Ar_3, depending upon which steel is used) as otherwise determined.

The experiment should be repeated several times and the average of the results determined.

Results: Table 1 gives results obtained by the writer and an assistant using the magnetic method as compared with results obtained by a class of advanced students, using pieces of the same steels and the cooling curve method.

During the past two years a large class of students who had had no previous experience with the apparatus obtained the results shown in Table 2, using in each case a high-carbon steel.

All the results shown were obtained under the supervision of the writer in the Metallurgical Laboratory of Harvard University under the general direction of Prof. Sauveur, whom the writer wishes to thank for several helpful suggestions.

As a Commercial Testing Method.—The method described in this paper being much more quickly performed than the cooling curve method might be used profitably in a commercial way for determining the critical points Ac_{3-2-1} and Ar_{3-2-1} in an unknown high-carbon steel where the best quenching temperature, for instance, might be desired. In this case ten readings or more could be taken in about twenty minutes. To do away with the effect of the personal equation of the observer who watches the test-piece the magnet core might be connected in a weak electric circuit with the test-piece, together with a buzzer or other indicator which would mark instantly the breaking or closing of the circuit caused by the fall or rise of the test-piece.

As an Automatic Device for Hardening Steel — It is suggested that the apparatus described might be used as an automatic quenching device for small steel articles without the aid of a thermo-couple. By making the electromagnet of the proper size and suspending small pieces of steel from it the latter on heating would drop off, each as it reached its critical point Ac_{3-2-1}, falling into a trough containing the proper quenching bath. The heating perhaps might be evenly accomplished by means of a hollow cylindrical electric resistance furnace without a bottom.

Harvard University.

Industrial Electrochemistry in Russia

An interesting Faraday Society paper of Prof. N. Piltschikoff, of the Technical Institute of Kharhov, gives a brief review of the electrochemical industries in Russia.

Besides three works, making caustic soda and bleaching powder, viz., Lubunoff, Solvay & Cie., Zabkowickie Electrochemical Cie. and the Russian "Elektron" Company, there are several copper-refineries, viz., that of the Siemens Company at Kalakant, which is not at present working, and a factory at Moscow which produces annually 500 tons of electrolytic copper, 1 ton of silver and about 80 lbs. of gold; tin, nickel and chromium are also prepared. There is also a similar factory at Petersburg, and a plant for the extraction of copper from its ores is erected at the "Medianke" mine at Boleslav.

"At the latter place the method of Laschinsky is used. According to his observations the salts of iron, even in small quantities, are oxidized at the anode to a sulphate very rich in iron:

$$2FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O.$$

This minimizes the effect of the current and lowers the quality of the deposit. To avoid this oxidation the plates are covered with lead which forms the anode in the electrolytic bath, while the liquid is continually stirred. The effect of this arrangement is remarkable, the iron is no longer oxidized, and copper is deposited regularly in amounts up to 1.15 grms. per ampere-hour."

Several electrochemical methods are about to receive a technical application. Among these, the process of fixation of atmospheric nitrogen by Gorbov and Mitkievitch, professors in the Institut Polytechnique in Petersburg, may be cited. Their furnace (Fig. 1) consists of a chamber B, whose upper part is formed by a funnel K, connected to a worm in which the products of combustion can be cooled. The arc is formed between carbon or metal electrodes C_1 and C_2, and fills the whole of the funnel. ("Continuous or alternating current can be used. The terminal voltage is from 1,000 to 3,000 and across the arc from 600 to 1,500.") A current of air draws the arc into the worm, in whose mouth is formed a "bunch of fire," through which all the air has necessarily to pass. It is then cooled in the worm, which is placed in a bath A filled with water or oil, whose temperature is not allowed to exceed a certain limit.

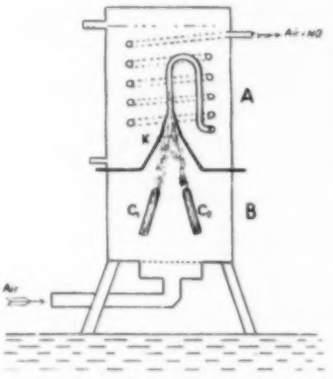


FIG. 1.—GORBOV-MITKIEVITCH FURNACE.

Fig. 2 shows the operation of a Gorbov & Mitkievitch furnace with a 12-kw. arc. The abscissae show the percentage volume of nitrous oxide obtained, while the ordinates are the weight of nitric acid in grams per kilowatt-hour. "This furnace has been compared with that of Birkeland and Eyde, and is found to be much more economical, while its construction is simpler."

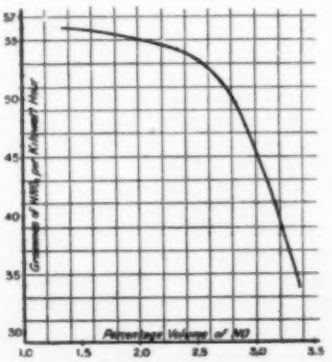


FIG. 2.—RESULTS OF PRODUCTION OF NITRIC ACID.

Prof. Kloboukoff, of Kharkov, has perfected the tanning of hides by the electric current, which prevents any fermentation in the bath. But these experiments have been interrupted by the death of Kloboukoff.

Dr. K. Danilevsky has studied the deposition of electrolytic copper on leather. The leather with its contained copper is harder, resists the action of lime to a greater extent, and wears out less quickly.

Successful experiments have been made at Petersburg on the purification of various waters by ozone. The process is not yet widely used, probably for economical reasons. The author has, however, seen at Moscow a very powerful and economical ozonizer due to Prof. Sokotoff.

Association of Electrical Engineers of the Iron and Steel Industry

The first annual meeting of the Association of Electrical Engineers of the Iron and Steel Industry will be held in Philadelphia on June 24 and 25. Mr. G. H. Winslow, 559 Frick Annex, Pittsburg, Pa., is the secretary and treasurer.

The following committees have been appointed: Finance, Messrs. E. W. Yearsly, G. H. Winslow, J. Farrington; papers, E. W. Yearsly, P. D. Brown, G. W. Richardson, G. M. Sturgess; library, G. H. Winslow, L. R. Palmer; board of examination, B. R. Shover, J. C. Reed, L. R. Palmer; editing, L. R. Palmer, G. H. Winslow; standardization, T. P. Townsend, G. W. Richardson, G. M. Sturgess.

Metallurgical Calculations.

BY J. W. RICHARDS,
Professor of Metallurgy in Lehigh University.

Condensation of Zinc and Mercury Vapors.

The temperature at which a metallic vapor, like zinc or mercury, commences to condense, depends upon the vapor tension curve of the metal and the amount of other uncondensible gas with which it is mixed. These intermixed gases reduce the pressure upon the metallic vapor, and lower the temperature at which the vapor becomes saturated vapor. The phenomenon is exactly analogous to the "dew point" of air and the preciptation of rain.

Problem 135.

A roasted zinc ore contains 15 per cent Fe^2O^3 and 70 per cent Zn O. It is reduced by excess of carbon, in a retort.

Required:

(1) The average composition, by volume, of the gas mixture entering the condenser, assuming no CO^2 in it.

(2) The "dew point" of the mixture at which it begins to deposit zinc.

(3) The percentage of zinc escaping condensation, if the gases leave the condenser at 600° C.

Solution:

(1) Per kilogram of zinc there is used, assuming complete reduction:

$$1 + (0.70 \times 65/81) = 1.78 \text{ kg.}$$

Oxygen in 1.78 kg. of ore:

$$\text{As Zn O} = 1 \times 16/65 = 0.246 \text{ kg.}$$
$$\text{As } Fe^2O^3 = 1.78 \times 0.15 \times 48/160 = 0.080 \text{ "}$$
$$\text{Sum} = 0.326 \text{ "}$$

$$\text{CO formed} = 0.326 \times 28/16 = 0.57 \text{ "}$$
$$\text{Volume of CO} = 0.57 \div 1.26 = 0.45 \text{ m}^3$$
$$\text{Volume of Zn} = 1.00 \div 2.93 = 0.34 \text{ m}^3$$

$$\text{Sum} = 0.79 \text{ m}^3$$

Percentage composition of gases:

$$\text{C O} = 57 \text{ per cent}$$
$$\text{Zn} = 43 \text{ "} \qquad (1)$$

(2) If the barometric pressure is assumed normal, then the zinc vapor supports

$$760 \times 0.43 = 327 \text{ mm}$$

and the temperature at which the mixture becomes saturated with zinc vapor is found from the table (see June number of this journal, p. 250) to be 847°. (2)

This is 83° below the normal boiling point of zinc.

(3) From 847° down, the vapor in the retort will be always saturated, its tension being found from the tables. The proportion of original zinc condensed, or remaining uncondensed, cannot be inferred simply from the vapor tension at any temperature. For instance, the vapor tension of the zinc at 600° C. is 12 mm of mercury column. The CO gas leaving the condenser at this temperature will, therefore, be at a tension of 760 — 12 = 748 mm, and will be accompanied by 12/748 of its volume of zinc vapor; as it came into the condenser it was accompanied by 327/433 of its volume of zinc vapor. The ratio of these two quantities or proportions represents the real fraction of the zinc escaping uncondensed; that is, the proportion escaping condensation, in terms of the total zinc concerned, is

$$12/748 \div 327/423 = 0.016 \div 0.773 = 0.008 = 0.8 \text{ per cent.}$$

The same result can be calculated in several ways. One is based on the datum that at any given temperature zinc vapor is 65 ÷ 28 = 2.3 times as heavy as CO gas.

Problem 136.

Numerous attempts have been made to reduce Zn O continuously in a blast furnace, and condense the zinc from the gases. In such a case, the gases will consist of zinc vapor, carbon monoxide and nitrogen, and the deficit of reduction heat must be obtained by the burning of carbon to CO at the region of the tuyeres. A low charge column must be used in order that the gases pass out hot enough to carry the zinc. Assume the gases to escape at 900° C., and the furnace to lose by radiation and conduction, etc., an amount of heat equal to the sensible heat in the blast used.

Required:

(1) The amount of fixed carbon to be charged into the furnace, per 2000 lb. of zinc.

(2) The composition of the gases leaving the furnace.

(3) The temperature at which these gases will begin to deposit zinc or become saturated with zinc vapor.

(4) The proportion of the zinc they carry which will escape from the condensers, as vapor, at 600° C.

(5) The pressure necessary to apply to the furnace to keep the zinc in the melted state at the minimum temperature of reduction, 1033° C.

Solution:

(1) If the reaction is assumed as practically

$$\text{Zn O} + \text{C} = \text{Zn} + \text{CO}$$

there is needed for reduction, per 2000 lb. of zinc

$$2000 \times (12/65) = 369 \text{ lb.}$$

There is in this reaction a deficit of heat, which is per 65 parts of zinc concerned simply

$$(\text{Zn, O}) - (\text{C, O}) = 84{,}800 - 29{,}160 = 55{,}640.$$

This deficit can only be made up by burning more C to CO right at the tuyeres. If two more atoms of carbon were burned we would have a little more than enough heat. We will, therefore, assume the reaction at the tuyere region as the using of one atom of carbon for reduction and of double as much for supplying the heat deficit, and since one volume of oxygen is accompanied by 3.81 volumes of nitrogen, the whole reaction will be

$$\text{Zn O} + 3\,\text{C} + O^2 + 3.81\,N^2 = \text{Zn} + 3\,\text{CO} + 3.81\,N^2.$$

The amount of fixed carbon necessary is approximately three times that necessary for reduction only and amounts, per 2000 lb. of zinc, to

$$36 \times \frac{2000}{65} = 1108 \text{ lb.} \qquad (1)$$

(2) The furnace gases, therefore, contain, by volume,

Zinc vapor	= 1	volume	= 12.8 per cent.
Carbon monoxide	= 3	"	= 38.4 "
Nitrogen	= 3.81	"	= 48.8 " (2)

(3) The gases will be saturated with zinc vapor when the partial pressure of the zinc, which is

$$760 \times 0.128 = 97 \text{ mm}$$

is equal to the maximum tension of zinc at the temperature attained. This is at **745°** C., as seen from inspecting the vapor tension tables, or 185° below the normal boiling point of zinc. (3)

(4) The relative volume of zinc vapor to uncondensable gas in the original gases is

$$\frac{12.8}{87.2} = 0.147$$

In the gases issuing from the condenser at 600° it would be

$$\frac{12.0}{748} = 0.016$$

The proportion of the zinc escaping condensation under these conditions would, therefore, be

$$\frac{0.016}{0.147} = 0.109 = 10.9 \text{ per cent.} \qquad (4)$$

By cooling the gases to the melting point of zinc, it would be possible to leave uncondensed only

$$\frac{0.165}{759.8} + 0.147 = 0.0014 = 0.14 \text{ per cent.}$$

(5) If it was a question only of keeping pure zinc from vaporizing at 1033°, in the absence of other gases, we could at once consult the vapor tension table, and find 2.2 atmospheres as the actual tension of zinc vapor at 1033°, corresponding to 1.2 atmospheres effective pressure upon the furnace. But in the gas mixture coming from the furnace the zinc is practically one-eighth, by volume, of the gases, which means that it sustains one-eighth of the pressure upon the whole. It would, therefore, take a tension of

$$2.2 \times 8 = 17.6 \text{ atmospheres}$$

to keep all this zinc in the liquid state, corresponding to an effective pressure of 16.6 atmospheres. (5)

This is an entirely impracticable working condition and shows the practical impossibility of the schemes upon which much money have been spent for reducing zinc ore to liquid zinc in a blast furnace run under high pressure.

Problem 137.

In the metallurgy of mercury, the average ore contains 2 per cent of Hg S and is roasted by the use of 10 per cent of its weight of wood having an average composition of water 20 per cent, carbon 32, hydrogen 5.3, oxygen 42.7. Assume that just enough air enters to completely burn the sulphur and carbon, that the ore and air used are dry.

Required:

(1) The percentage composition by volume of the roaster gases.

(2) The temperature at which the mercury will commence to condense.

(3) The proportion of the mercury present escaping as vapor if the gases pass out of the condensers at 100° C., at 50° C., at 15° C.

Solution:

(1) Per 1000 kg of ore, containing 20 kg of Hg S, there must be burned

$20 \times 32/232 = 2.8$ kg of sulphur.
$100 \times 0.32 = 32$ " " carbon.

requiring of oxygen:

$2.8 \times 1 = 2.8$ kg.
$32 \times 32/12 = 85.3$ "
Sum = 88.1 "
Nitrogen accompanying = 293.7 "
Air = 381.8 "

Composition of the gases:

Hg =	17.2 kg =	17.2 ÷ 9.00 =	1.91 m³ =	0.595 per cent
SO^2 =	5.6 " =	5.6 ÷ 2.88 =	1.91 " =	0.595 "
H^2O =	68.0 " =	68.0 ÷ 0.81 =	83.95 " =	26.15 "
N^2 =	293.7 " =	293.7 ÷ 1.26 =	233.10 " =	72.66 "
			321. " =	100.00 (1)

(2) In reality, each of these gases possesses the volume of the gas mixture, and is at the above percentage of the normal barometric pressure upon the mixture. The tensions of the different constituents of the mixture are, therefore,

Hg	760 × 0.00595 =	4.52 mm
SO^2	760 × 0.00595 =	4.52 "
H^2O	760 × 0.2615 =	198.75 "
N^2	760 × 0.7266 =	552.20 "
		760.00 "

The mercury will, therefore, commence to condense when the temperature of the gas mixture is that of mercury vapor at a maximum tension of 4.52 mm. From the vapor tension table of mercury we find this to be 161° C., or 196° below the normal boiling point of mercury. Above this temperature the gas mixture is not saturated with Hg vapor and no condensation can occur. (2)

(3) In the gas mixture, the mercury vapor is equivalent to 4.52/760 of the volume of the whole, or 4.52/755.48 of the volume of the other gases. This latter proportion is 0.00598. At 100° C. the uncondensed mercury vapor can have a tension of 0.285 mm, leaving 759.715 to the other gases, and giving the ratio of mercury vapor to other gases 0.000375. Since the other gases have remained constant in amount, the proportion of mercury remaining uncondensed is

$$0.000375 \div 0.00598 = 0.063 = 6.3 \text{ per cent.}$$

If the temperature of the mixture is reduced to 50° C., the mercury vapor remaining can exert a tension of only 0.013 mm and the water vapor only 92 mm. The other gases present will therefore sustain $760 - (92 + 0.013) = 668$ mm. In the original mixture the Hg and H^2O vapors are, respectively, equivalent to

Hg 4.52 ÷ 556.72 = 0.0081
H^2O 198.74 ÷ 556.72 = 0.3570

of the volume of N^2 and SO^2 together.

In the gas escaping at 50° the Hg and H^2O will be equivalent to

Hg 0.013 ÷ 668 = 0.00002
H^2O 92. ÷ 668 = 0.1377

of the volume of the same gases.

The proportions of the Hg and H^2O escaping uncondensed at 50° will, therefore, be

Hg 0.00002 ÷ 0.0081 = 0.0025 = 0.25 per cent
H^2O 0.1377 ÷ 0.3570 = 0.3857 = 38.57 per cent.

By exactly similar reasoning, using the maximum tensions of Hg and H^2O at 15° (0.0009 mm and 13 mm, respectively), the proportions of each to the $N^2 + SO^2$ are

Hg 0.0009 ÷ 747 = 0.0000012
H^2O 13. ÷ 747 = 0.0174

and the proportions escaping condensation would be

Hg 0.0000012 ÷ 0.0081 = 0.00015 = 0.015 per cent
H^2O 0.0174 ÷ 0.3570 = 0.04874 = 4.874 per cent (4)

The differences between these percentages and 100 will be the proportions of these materials condensed to the liquid state.

METALLIC MIST OR FUME.

When zinc or mercury are in the state of vapor their atoms are each separate from other atoms. Chemically speaking, their vapor molecules are mon-atomic. On condensing to the liquid state we do not know whether the atoms come together into compound molecules or whether they simply come closer together. In either case, the molecules of the liquid metal, as the temperature is reduced low enough to form them, exist at first as isolated molecules, constituting the liquid metal in its finest possible state of sub-division, so small that it is for the time being practically still a gas. If, however, we give these liquid molecules the possibility of uniting to liquid masses, we get the latter. This is a matter principally of reducing the surface tension which holds the liquid molecules each to itself as a sphere. Contact with a rubbing surface, with dust particles, filtration through cloth, or even electrification (perhaps a magnetic field) reduce this surface tension and cause agglomeration into liquid masses which precipitate.

The amount of liquid or solid particles thus held in suspension and escaping with the current of uncondensable gas is entirely independent of the quantity escaping as true vapor, which has been calculated above, except in so far as they are both functions of the amount of said uncondensable gas. The velocity of the escaping current is a large factor in the amount of mist, because the carrying power of gas for mist particles varies probably with the cube of its velocity, so that halving the velocity of the issuing gas will diminish greatly this source of loss. Large settling chambers in which the mist can deposit, because of stagnation of the gas current, and large rubbing surfaces, are effective means for catching or depositing the mist. Filtration through bags is still more effective.

In the case of zinc, the solidifying point is 420°, while condensation from the state of vapor begins at, say, 860°. In this interval only can the condensed particles, as a mist, collect

together to liquid zinc. If the temperature passes quickly through this range, the particles have little chance to agglomerate into liquid masses, and the proportion which chills into solidified mist particles is increased. These solidified mist particles, analogous to "hoar frost" in nature, form the well known "blue powder" of the zinc works. It settles in large settling chambers, and is in extremely fine particles, mostly under 0.01 mm in size. It is quite easy to collect all the zinc in this form if the vapor is chilled suddenly and the resulting gas settled properly or filtered.

The loss of mercury or zinc as mist or hoar frost is therefore, to be considered entirely apart from the loss as true vapor; it may be smaller than the latter and it may be larger; its amount varies particularly with the nature of the settling apparatus and the velocity of the gases as they escape. The theory as to its amount under any given set of conditions would be very difficult to elaborate, and the data for doing so with exactness are practically unknown. The best that can be done at present is to study the loss as mist or hoar frost in actual practice, experimentally, and tabulate the actual results as a guide for future metallurgical use.

The Silver Refinery of the New Addition to the Raritan Copper Works.

BY FRANK D. EASTERBROOKS.

Silver Refinery.—The slimes deposited in the bottom of the tanks from both the No. 1 and No. 2 tank houses are treated in this department for the recovery of fine silver and gold.

The process of smelting and refining is divided into three stages, each of which is carried out in a separate room. Fig. 1 shows a ground plan of the refinery.

On account of the high monetary value of the material handled, precautions have to be taken to guard against losses other than metallurgical. In Fig. 6 is shown the arrangement of lockers, etc., for the employees, which may be of sufficient interest to describe them in greater detail.

Special provision was made for the comfort and convenience of the working force, white porcelain-lined wash stands, hot

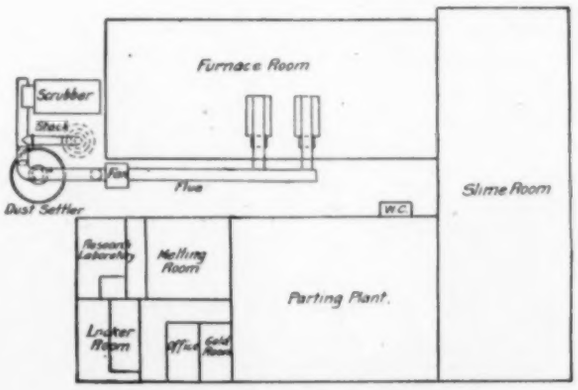


FIG. 1.—PLAN OF SILVER REFINERY.

and cold water and shower baths being provided, together with two lockers for each employee, one for his street clothes and the other for his working apparel, the idea being that if comfortable, scrupulously clean and sanitary surroundings were provided, a standard would be established, whereby the force could be held and maintained at that degree of cleanliness and carefulness which is so essential in the successful operation of a refinery treating electrolytic slimes.

All employees enter the No. 1 locker room by the door nearest the entrance, remove their outside street clothes, place them in their respective lockers and pass through the door leading to the No. 2 locker room. This door is opened from either side only by a key which is in the possession of the special watchman. After donning their working clothes, the men go directly to their respective departments without passing through either of the others. On leaving work the reverse takes place, the laborers first washing up (the waste waters from the sink going to suitable settling tanks) before passing through the door to the No. 1 locker room. All the windows of the refinery are protected by small diamond mesh screens.

The buildings were constructed of brick with monitors running the length of the roof for ventilating purposes, with the

FIG. 2.—FILTER PRESS FOR SLIMES.

exception of the melting room in the parting plant, where two 48-in. Burt ventilators were installed. The roof trusses in the slime room are of timber, while those in the furnace building and parting plant are of steel.

A 5-ply asphalt and slag roofing laid over book tile was used in place of planking in the parting plant to prevent the possibility of a fire from spontaneous combustion, due to the action of nitric acid fumes on wood. All flashing throughout was of 16-oz. copper, and exposed woodwork both inside and outside of the building was covered with three coats of Toch Bros. iron oxide paint.

The following gives an outline of the process for smelting slimes:

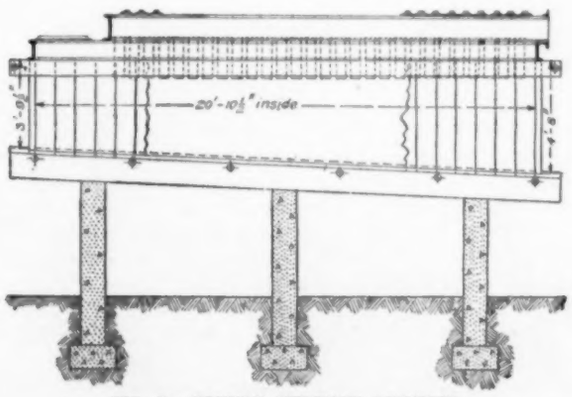


FIG. 3.—SECTION THROUGH SCRUBBER.

Stage.	Department.	Treatment.
1st	Slime room	Copper extracted. Slimes pressed and washed.
2d	Furnace room	Slimes melted and blown up to bullion.
3d	Parting plant	Gold and silver separated electrolytically.

Slime Room.—The general scheme for handling the slimes here is by the gravity system. After being screened first

through a copper plate perforated with 1-in. holes, then through a slotted copper screen equivalent to 40 mesh to remove as much of the copper as can be removed by screening, the slimes are pumped from the tank house basement to receiving tanks in the top of the slime room by a centrifugal pump of the same design as that used for circulating electrolyte in the tank house.

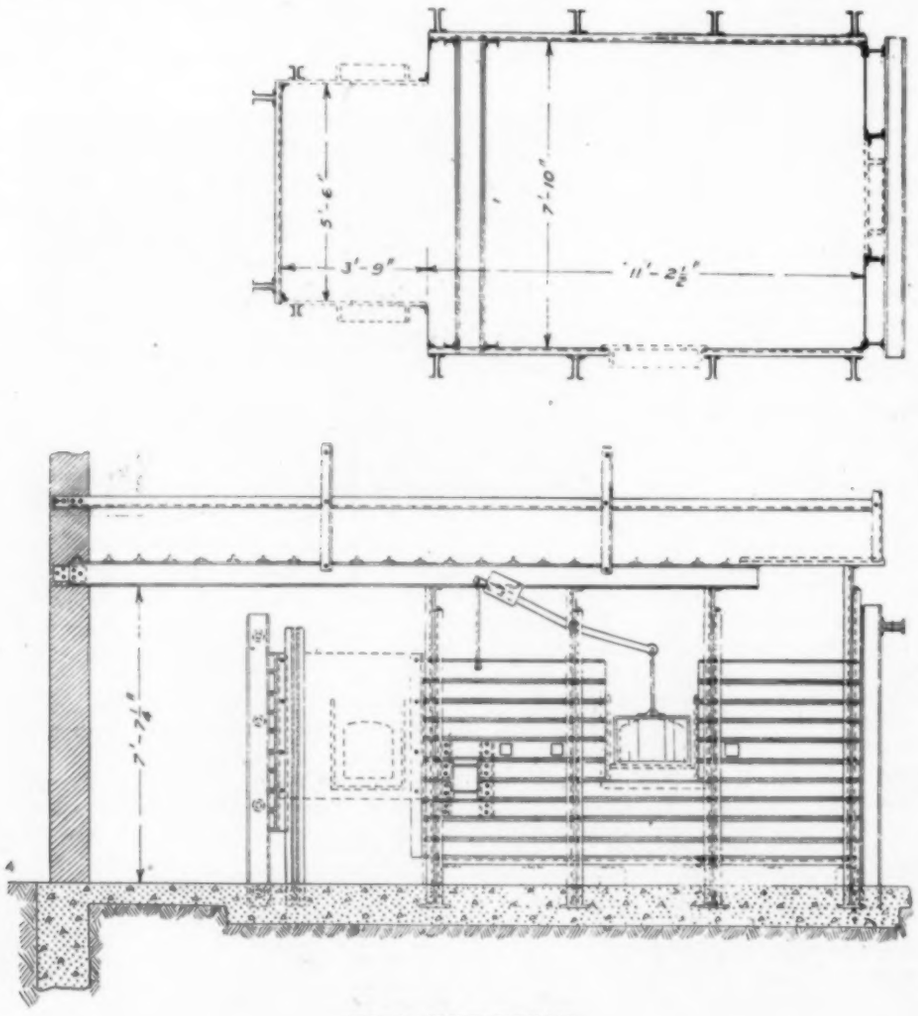


FIG. 4.—SLIME FURNACE.

All overflow water, together with the water used for washing slimes in the filter press, is returned to the tank house, where it is added to the electrolyte to make up losses by evaporation, etc., the water first passing through a system of settling tanks arranged on the gravity plan to allow the lighter particles to settle. The slimes are transferred from the receiving tanks to the agitators through a pipe and plug seat located in the bottom of the receiving tank.

In the agitators, which are large, circular, lead-lined tanks, the slimes are boiled with sulphuric acid, sodium nitrate being added to hasten the process. Paddles constructed of lead containing 10 to 12 per cent antimony and turned by machinery, prevent the slimes from settling to the bottom of the tanks in a solid mass. Practically no difficulty whatever is experienced with the machinery in this room due to acid fumes, and the use of machinery tends toward reducing labor costs.

After the copper in the slimes is reduced to a small amount they are transferred to an "egg"—a lead-lined cast-iron vessel, from which, by means of compressed air, they are forced into the Bushnell filter press, where the slimes are pressed and washed free from copper sulphate. Fig. 2 shows a photograph of the filter press.

The plates and rings of this press are made of antimonial lead heavy enough to withstand the pressure used. Sulphuric acid solutions gradually attack plates made of copper or copper alloys.

The pressed slimes are unloaded directly into trucks which are run in under the press. After sampling and weighing they are ready to be transferred to the furnace department. It will be noted that this is the first point where a determination is made of the actual amounts of silver and gold recovered from the copper bullion.

The amount of copper remaining in the screened slimes varies from 8 to 18 per cent; in certain cases where anodes are cast directly from converter copper, it will assay as high as 50 to 53 per cent. The leaching of this copper from slimes is made necessary because of the fact that when smelted in furnaces copper and silver form a compound assaying very high in silver, which is "slagged off." This not only diminishes the immediate output, but also increases the amount of silver tied up in process, thereby extending the time necessary to ship as fine product.

The method of extracting copper by boiling with acid and nitre is a slow reaction, despite the fact that copper exists in the slimes in a minute form. The process leaves much to be desired. Ten to 15 days' time is required to ship slimes as fine silver and gold, calculating from the date they are received from the tank house.

Furnace Room.— In this department the slimes are smelted in furnaces and refined by means of air blown on the molten surface to about 98 to 99 per cent gold plus silver.

Fig. 4 shows views of the furnace used to smelt slimes. The hearth is made of chrome brick,

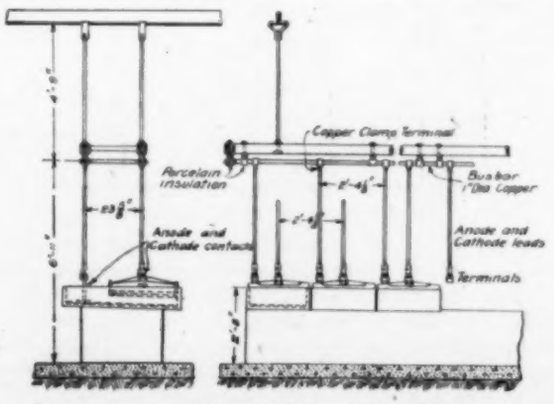


FIG. 5.—SECTIONS OF COMPLETE CELLS.

and is 5 ft. 6 in wide by 8 ft. long. Oil is used for fuel, burners furnished by the Rockwell Engineering Co. being used. In the refining process, tellurium is among the last of the impurities to leave silver bullion, its presence re-

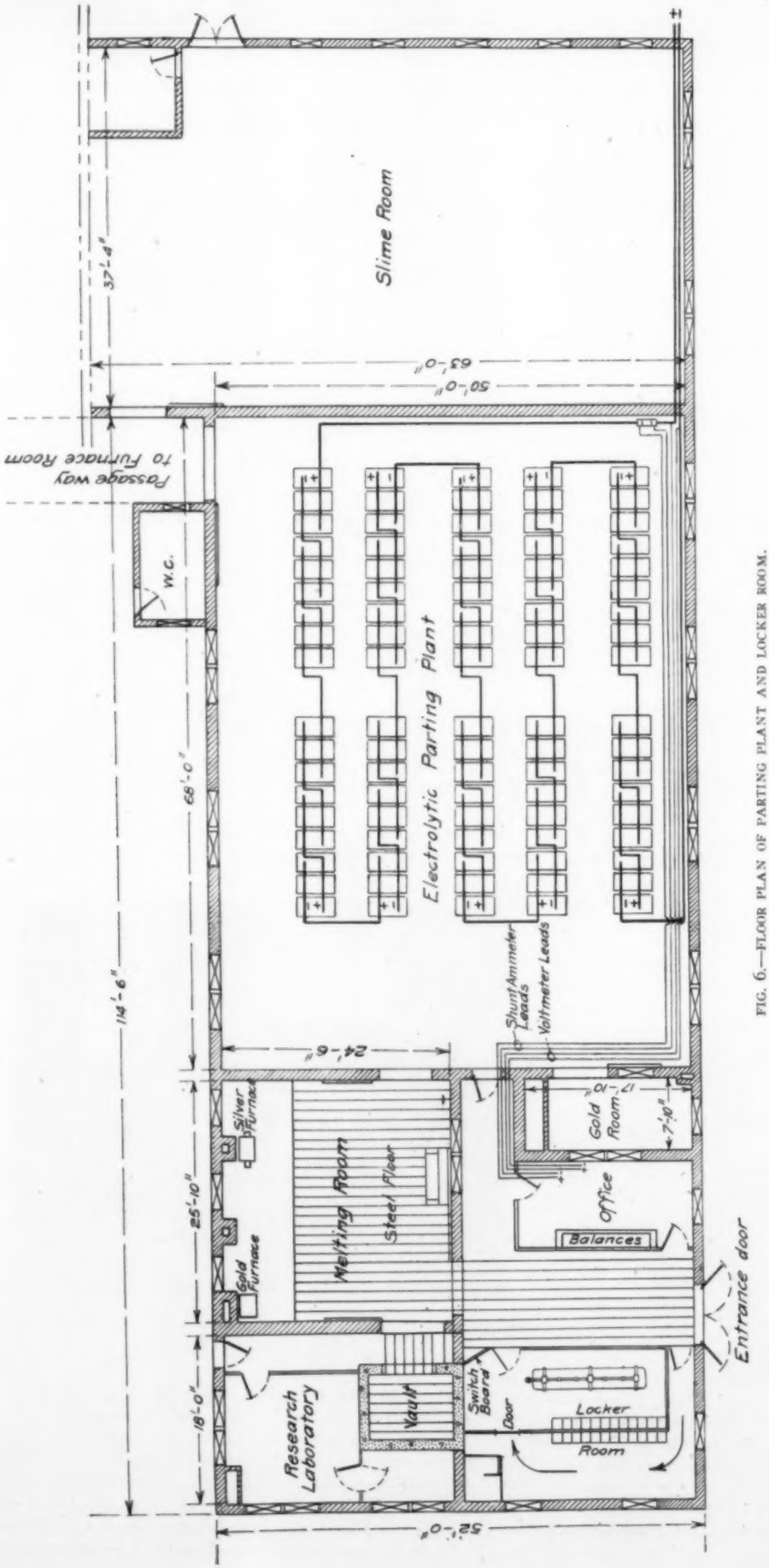


FIG. 6.—FLOOR PLAN OF PARTING PLANT AND LOCKER ROOM.

quiring a prolonged operation with an accompanying loss of silver. The reason why loss of silver occurs when melted in open furnaces has been pointed out by Prof. J. W. Richards in his series of Metallurgical Calculations. (See ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, March, 1908, page 115.) His theoretical conclusions are confirmed in actual practice.

The refined bullion is dipped from the furnaces and cast by hand into thin plates, which form the anodes used in the electrolytic parting plant.

No lead is used in refining slimes, and the slags, after sampling and weighing, are sent to the copper furnaces. This tends, of course, toward a gradual increase of impurities in the material handled.

For recovering values mechanically carried into the flues, or volatized during the smelting process, an arrangement of flues shown in Fig. 1 was constructed. The gases are exhausted from the furnaces by a fan which forces them first through a large settler, to allow the greater part of the dust to settle, and then through a water scrubber, before escaping to the air. In Fig. 3 is shown a view of this scrubber.

Slimes as charged into the furnaces contain from 40 to 50 per cent silver, together with considerable gold, depending upon the copper bullion refined.

There is need of intelligent, earnest, systematic research work in the method of refining slimes, particularly on slime room and furnace methods, and the establishment of a research laboratory by the consulting engineers, Messrs. Fischer and Nevill, was in line with the advanced policy pursued by them throughout the construction of the plant.

Parting Plant.— After investigating different processes in use for the electrolytic separation of gold from silver, the method devised by Mr. William Thum, which is a modification of the method described in full in his patent specification (U. S. Patent No. 58,035), was the one adopted as best suited for the work in hand.

The chief difference between this method and Balbach's (U. S. Patent No. 588,524) is, that in the former the electrodes are set at a slight incline from the horizontal, thus permitting solutions of

heavier specific gravity which are formed directly under the anode case to mix more readily with the rest of the electrolyte. In the Thum process a flexible arrangement of cells can be made, whereby the current used may be shunted from the tank house electrolytic circuits. This provides cheap power and does away with the necessity of installing separate generators.

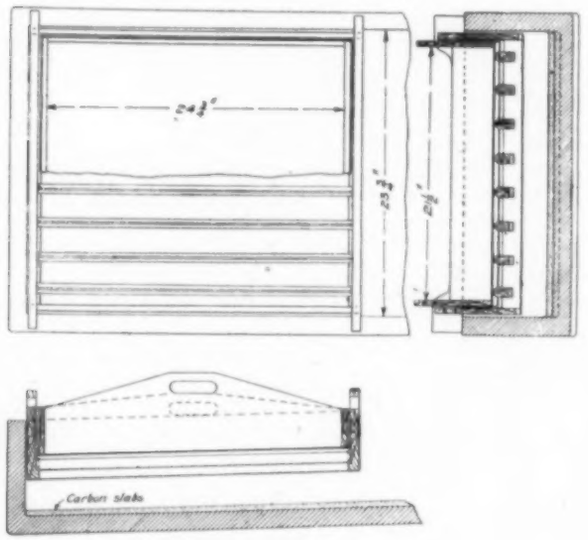


FIG. 7.—DETAILS OF ANODE CASE.

The cells are constructed of white acid-proof chemical stoneware, the bottoms of which are lined with flat slabs of carbon carefully fitted so as to make tight joints. These form the cathodes. Fig. 7 shows details of the anode case and Fig. 5 cross and longitudinal sections of complete cells. Three cells are in parallel, with 3.5 sq. ft. of anode surface per cell. A current density of 40 amperes per sq. ft. is used.

The cathode contact pieces are cast of fine silver and last indefinitely. Anode contacts are cast of bullion. These contacts are cast in specially constructed molds, a threaded end being cast directly from the hot metal. In Fig. 8 is shown a detail of the method of connecting silver contact pieces with the busbar which runs overhead.

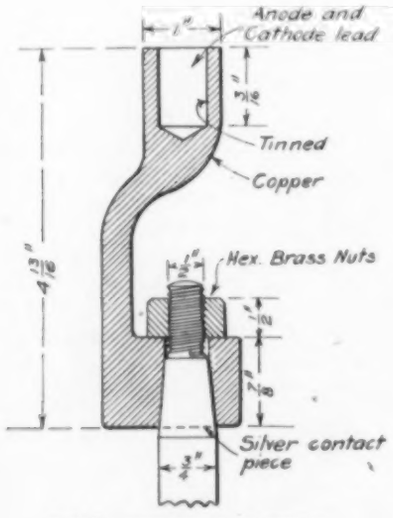


FIG. 8.—CONTACT CONNECTION.

The general arrangement of plant is such that one aisle is used exclusively for the removal of deposited silver and the adjoining one for the removal of gold mud which remains on the canvas tray. Deposited silver is scraped from the bottom of the cells, removed in trucks and washed free from the copper silver nitrate electrolyte. A hard rubber pump furnished by the American Hard Rubber Co. handles the wash water and raises it to a storage tank.

After washing and drying, the silver is melted down in a tilting crucible furnace, and cast into bars weighing approximately 1000 troy ounces, assaying 999 parts per 1000 fine silver. Fig. 9 shows a view of the furnace used for melting fine silver. The gold mud is removed in trucks, boiled first in nitric, and finally in sulphuric acid. It is melted in an oil-fired crucible furnace made by the Rockwell Engineering Co. In Fig. 10 is shown a view in a sulphuric acid parting plant, which is in sharp contrast with the appearance of an electrolytic parting plant.

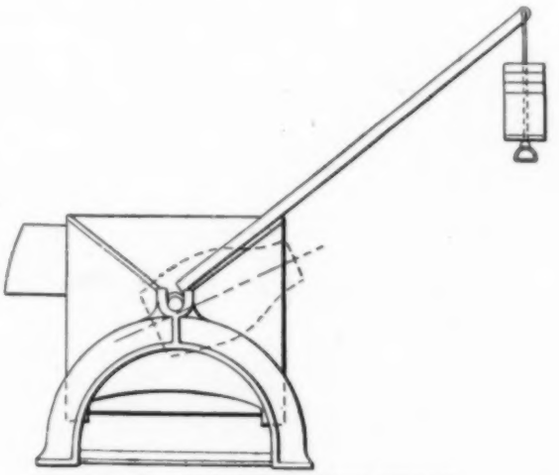


FIG. 9.—FINE SILVER MELTING FURNACE.

Sulphate Building.—Waste solutions from both tank houses are worked up in this department. The free acid is neutralized by allowing it to flow over shot copper, the copper being exposed alternately to solution and air. After concentration, the solution is run into small tanks where the bluestone crystallizes on lead strips. Fig. 11 is a view of a conical screen used for drying and sizing the crystals.

FIG. 10.—PRECIPITATING AND WASHING TANKS IN OLD (SULPHURIC ACID) SILVER REFINERY.

Foundry Machine Shop and Smithy.—A word should be said in regard to these departments, which play an important part in the economics of copper refining; the necessity of mak-

ing repairs quickly, and of keeping the mechanical equipment in perfect working condition being of prime importance.

The foundry building is a frame structure 49 ft. x 56 ft., and is equipped with a 6-ton crane. An elevated trestle, which is used for conveying pig iron, coke, etc., connects the railroad track directly with the charging floor of the cupola.

All the iron molds used for casting copper anodes are poured

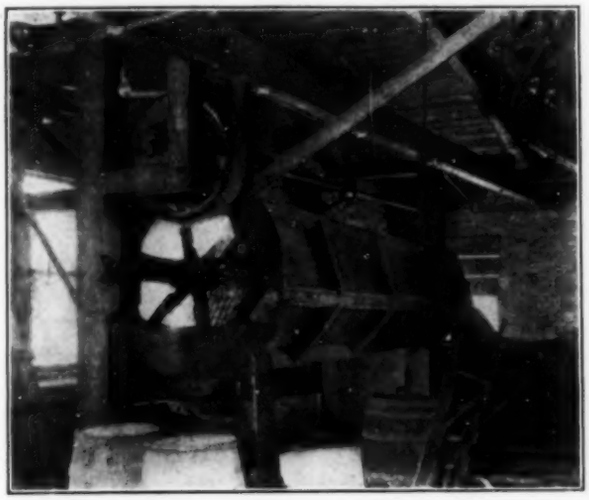


FIG. 11.—SCREEN FOR BLUE VITRIOL.

here, as well as the necessary parts needed for making repairs.

The smithy is a building of brick construction 20 ft. x 67 ft., a large monitor providing ample ventilation. Besides the customary forges, it is equipped with a steam hammer, punch and shears. The machine shop is a combination brick and frame structure 49 ft. x 80 ft. It is painted white inside which, together with the large number of windows, gives a well-lighted interior. The building is divided into three bays, while a crane in the middle bay provides facilities for handling heavy work. The equipment includes a milling machine, 5-ft. radial drill, grinder, 30-in. planer and one 14-in., two 18-in. and one 28-in. lathes.

Hard Spots in Steel Castings, with an Account of Certain Diffusion Phenomena.

BY ARTHUR P. SCOTT.

To the machinist and roll-turner the occurrence of hard spots in castings is not an unusual thing. In the case of cast iron the fault is promptly laid, for the most part, to "chill," which evil, being fairly well understood and having attained a certain traditional dignity, is accepted with more or less of philosophy. Not so with cast steel. To begin with, the trouble is less frequently met with, and so causes more comment; also, it is not so well understood when it does appear, and therefore must be blamed upon some one.

In such event an all too common procedure is this: The foreman of the machine or roll-shop lays a highly generalized complaint before the superintendent. On his next round of the works the latter official, not for cause proven, but on the accepted principle of periodically prodding all and sundry, administers a wigging to the foundry foreman, who, smarting, visits the plaintiff. In the wordy war which ensues the machinist makes stormy and redundant reference to "segregation," while the foundryman descants upon the futility of tool-steels and tool-dressers, generically and specifically. Follow personalities and an *impasse*, which is eventually relieved by the happy suggestion, "We'll get an analysis on that."

This one remaining stepping stone to retreat with honor is accepted with much solemnity by both combatants, who go their several ways in peace. (Volumes might be written on "The Laboratory in Diplomacy!") An order presently filters through to the machine where the offending casting is set up, and drillings are obtained and sent to the laboratory "for complete analysis." Quite obviously, a metal that has turned the edge of the best cutting-tool available will not yield to the drill; so that the sample received by the chemist, though taken ever so close to the seat of the difficulty, may be quite irrelevant; but this is of little consequence, seeing that by the time the analysis is reported, the incident has been whirled from view in a cloud of other troubles.

Nevertheless, since after such an interview every right-thinking foreman impartially reprimands all his subordinates, on one pretext or another, and since in an old and well established industry, nearly every difficulty, understood or not, arises simply from someone's failure to take pains, great good accrues from a small evil—good to operation, that is—the net gain in actual knowledge is nil.

A discussion of the extent to which investigation should be encouraged by the modern steelmaker is not within the scope of this paper; suffice it to say that it has been the writer's good fortune to have colleagues who, for the most part, have maintained toward the laboratory an attitude much more encouraging than the one just outlined, and who, while always "out for tonnage," have yet found time to appreciate a crumb of truth for truth's sake. Thus, when a few months ago, in turning up a steel roll in our roll shop, a hard spot was encountered, it was drilled out bodily, and sent to the laboratory for examination. The results of our work in this connection proved to be of considerable interest, and are given here in detail.

The casting in question was for the middle roll of the roughing set of a three-high rail-mill. The steel was tapped from a fifty-ton basic open-hearth furnace into a fifty-ton ladle, whence, after carbon and manganese additions—the former in bags of coke dust, the latter as cold 80 per cent ferromanganese—the necessary quantity was bottom cast into a swept, silica-washed, dry-sand mold. Near the end of the cast, about twenty pounds of ordinary black thermit was added in the riser. The rough casting weighed approximately 22,000 lbs.

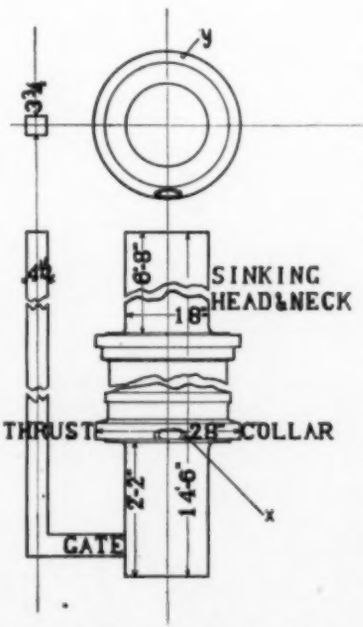


FIG. 1.—CASTING AND HARD SPOT X.

The mold stood in the same pit as the ladle during tapping, and about ten feet away from it; but the top of the former was five feet above the floor from which the furnace helpers made the ladle additions, the brim of the ladle being about three feet below the level of this floor. The tapping temperature was not recorded; the indications are that it was normal. The ladle nozzle was of one and three-quarter inches diameter.

The casting was duly cooled, cleaned, sent to the roll-shop and set up in a lathe, where work proceeded smoothly enough until, in turning up the face of the thrust collar on the bottom end, a spot was encountered, so hard that the best tools available merely jumped over it, leaving barely a scratch behind them. The

hard spot seemed to be associated with a lenticular cavity whose mouth was situated immediately beneath it, and opened on the bottom side of the collar. The somewhat unconventional drawing in Fig. 1 gives a general idea of the casting, and of the location of the hard spot X. The cross section shows a bottom view of the casting minus the gate. Thanks to its position, the defective portion was removed readily, and without in any way damaging the roll, which was finished without further untoward event, and, with the usual intermissions, has been in service ever since.

It is at once apparent that the defect under consideration belongs to the class referred to by Henry D. Hibbard (*Trans. Am. Inst. Min. Eng.*, Vol. 23, p. 626). He says: "There is one of the ills that steel is heir to, that I conceive to be the result of a kind of local segregation, namely, the hard spots sometimes met with near the surface in machinery, both castings and forgings. It is common to ascribe these to particles of spiegel or ferromanganese remaining unmelted or unmixed in the steel. This explanation seems to me to be entirely inadequate. They occur in cases where it is impossible that any of the spiegel could remain unmelted or unmixed. As far as I have been able to observe, they occur in steels cast at too high a temperature.

"My theory for the case is that there is local segregation of the impurities at many places, each of which forms a hard spot near the outside of the mass of pasty steel, each hard spot being a joint where impurities were collected. Gaseous impurities are collected as well, and I have often noticed in forgings which have been insufficiently worked under the hammer, that almost every hard spot had a partially closed up hole, close to, or directly in it."

Now, if we assume the hardness to be due to lack of uniformity in chemical composition, we should very naturally expect to find, from hard spot to surrounding steel, a gradual shading down of the hardness, a gradually decreasing percentage of the hardening element or elements. We should expect this to be true if segregation were the cause of the non-uniformity, and equally so if the distribution had been faulty, because one unconsciously compares the dissolving of a fragment of ferromanganese in molten steel with the dissolving of a crystal of sugar in a glass of water; one thinks of it as a process of attack, proceeding from surface to center, concurrently with the diffusion of the portion already dissolved through the surrounding liquid. It came, therefore, as a distinct surprise when careful examination—macroscopic, microscopic and chemical—of the excised portion of our roll revealed the state of affairs shown in Fig. 2.

FIG. 2.—SECTION THROUGH CAVITY.

This is a section of the specimen through the long axis of the cavity and parallel to the long axis of the roll. A is the cavity; the shaded portion, B, is the hard spot, surrounded by C, the normal steel of the roll. We shall consider them separately.

A, the cavity, is lenticular in shape. Its long axis is parallel to the cooling surface of the casting. Its lips are rounded. Its maximum interior dimensions are, roughly, 12x6 centimeters, contracting to 9x4 centimeters at the mouth. It is about 6 centimeters in maximum depth. Its interior surface is of a brownish color, is free from angles, continuous, smooth, free from scale, and concave, suggesting in every way that its gaseous contents have exerted marked pressure upon the surrounding mass during cooling.

Cavities in steel castings are usually described under two heads—shrinkage-cracks and blowholes. Blowholes are subdivided according as their origin is intrinsic or extrinsic to the molten metal, *i. e.*, into 1, those which are caused by gases expelled from the metal on cooling, and 2, those which are due chiefly to imperfect drying or venting of the mold. Each class has its own distinguishing characteristics, and enough has been said to indicate that the cavity in question is not a shrinkhole, and, further, that it bears little or no resemblance in shape, surface or orientation, to the types of blowhole more usually included in class 1. Indeed, the evidence thus far adduced would point rather to class 2 only. It is somewhat too remarkable that mold defects should so frequently coincide exactly with hard spots, and it seems far saner to assume a casual relationship.

B, in Fig 2, was found to be a manganese-iron-carbon alloy of the following composition: Iron, 84.43; manganese, 11.87; silicon, 1.72; carbon, 1.81; phosphorus, 0.110; sulphur, 0.016.

The alloy constitutes an apparently unbroken envelope about the cavity, and from a maximum thickness of in the vicinity of two centimeters at the lips, tapers away to less than one millimeter at the apex, in a manner that irresistibly suggests the appearance of the bubble one blows in the wall of a glass tube preparatory to perforation. This envelope is, as it were, completely embedded in the steel, from which, though closely adherent to it, without any sign of dehiscence, it is at all points quite distinct. Nowhere is there any perceptible approach to coalescence.

This differentiation is very beautifully shown on polishing, when the sharp dividing line between the gray steel and the bright yellow manganese alloy with its characteristic markings in relief, becomes strikingly apparent. The polishing process, it should be remarked, was an invaluable aid to the preparation of samples for analysis. Our method was to break off a fragment from the main specimen; to grind and polish this fragment on two opposite sides; to take drillings of the steel from the polished surfaces at any desired distance from the dividing line; and, finally, following the line, to grind off all the adherent steel, leaving only the alloy, which could then be beaten up in a "diamond" mortar.

Photomicrograph 1 was prepared from a polished and etched section of the original specimen. The upper portion depicts the steel with some very pretty patches of lamellar pearlite. The lower part is the manganese alloy. There is nothing very striking about the appearance of the latter as here exhibited. Several very beautiful microscopic structures were observed in the alloy, but have been purposely omitted, the object of the photograph being merely to illustrate the line of partition.

The chemical composition of our alloy, taken in conjunction with its sharp differentiation from the steel, was somewhat puzzling. Segregation as a possible cause of the phenomenon—that is, segregation in the commonly accepted sense of the term—is entirely out of the question; more especially since, as is well known, and as has been repeatedly proven true in the writer's experience, manganese, under ordinary conditions, shows less tendency in this direction than any of the other elements commonly component of steel.

On the other hand, it is definitely known that when the roll was cast, an 80.00 per cent ferro was the only manganese alloy in the mill; and every lot of ferro ever used there conformed fairly closely to the average analysis quoted below. The only other manganese alloys that had at any time been used in the mill were spiegeleisen and silicospiegel, and they were always separately stocked.

In any case, admitting the remote possibility that some remaining lump of these poorer alloys had become mixed with the ferro that was employed for this particular casting, we are no nearer a satisfactory explanation than we were before, as will appear from the following table of average analyses taken from our stock book:

TABLE I.

	Carbon.	Manganese.	Silicon.	Phosphorus.	Sulphur.
Ferromanganese	6.60	79.87	.56	.250	trace
Spiegel	4.43	21.45	1.69	.104	.024
Silicospiegel	...	21.44	8.82	...	...

To none of these does our alloy correspond, and the only justifiable inference appears to be that it is an alteration product, probably of ferromanganese. One point more—it is unlikely, from the relative positions of mold and ladle, that any frag-

ment of ferromanganese intended for the ladle, could accidentally have fallen into the mold. We, therefore, provisionally conclude that it was added to the ladle in the usual way, but failed of perfect distribution.

NO. 1 × 100 D.

NO. 2 × 100 D.

MICROPHOTOGRAPHS NOS. 1 AND 2.

C. Analyses were made of nine separate samples of drillings of the steel proper, C (Fig. 2), taken from as many different holes. Hole No. 1 was ½ inch in diameter, and drilled close to the envelope B. Holes 2 to 8 inclusive, were ⅜ inch in diameter, and were drilled at varying distances from B, but all within ten centimeters of it. Hole No. 9 was ⅞ inch in diameter, and was drilled from the original roll at the point Y (See cross-section Fig. 1), diametrically opposite to the position of the blowhole. Note the analytical results:

TABLE II.

Drill-Hole No.	Carbon.*	Silicon.	Phosphorus.	Sulphur.	Manganese.
1.	.57	.135	.035	.033	.85
2.	.54	...	...	...	.86
3.	.52	...	...	...	.86
4.	.53	...	...	...	.84
5.	.53	...	...	...	.84
6.	.53	...	...	...	.86
7.	.52	...	...	...	.84
8.	.54	.147	.031	.029	.84
9.	.56	.170	.030	.030	.88

* Determined by combustion.

Clearly, if the ferro have lost manganese, phosphorus and carbon, the steel surrounding the residue was not thereby the gainer.

At this point in the investigation, it became apparent that our specimen must be regarded as an exception unless we could multiply examples, or else reproduce the phenomenon at will. Following the latter course, we made numerous experiments with fragments of ferromanganese and thermit iron, with no result other than a number of manganiferous nodules of most uncompromising hardness, that left no doubt in one's mind as to the thoroughgoing nature of the diffusion that had there transpired. After equally unsuccessful endeavors in other directions, we tried a method which, after a short explanatory note, we shall outline.

From every heat of steel that is tapped in an open-hearth mill, a test ingot is taken from the ladle at the pouring platform, usually, when about half of the heat has been teemed; and a convenient mode of taking it, is to hold the small iron test-mold on a peel under the nozzle of the ladle, while the leverman allows a small stream of the steel to run into it.

The resultant ingot is readily knocked out of the mold, and, when properly cooled, is drilled for analysis. The shape and dimensions of the test ingot used in our laboratory are shown in Fig. 3. Such an ingot weighs about 1 kilogram. Blowholes and shrinkage, it is scarcely necessary to mention, are responsible for the difference between this figure and the calculated weight.

Our final attempt was as follows: Having set a small pyramid of ferromanganese in the center of the bottom of one of the little test molds, we filled the latter with molten rail-steel during the teeming of a heat, in the manner just described for the usual ladle test. The test ingot thus obtained, on removal from the mold, showed plainly on its bottom the outlines of the base of the pyramid embedded in the steel, and apparently unaltered.

With the aid of a hack-saw and wedge, a slice was cut from the center of the ingot, through the lines *l* and *m*, Fig. 3, followed by a vertical bisection of the slice, at right angles to these cuts, so that an approximate bisection of the pyramid was obtained. To a height of perhaps 0.4 cm. above the bottom of the mold the ferro was unchanged, but above this there was a sharp alteration in appearance.

The pyramid seemed to have materially increased in bulk, and a tiny vermiform blowhole had developed about its central axis. Polishing revealed the fact that it was everywhere quite distinct from the surrounding steel, and its manganese content was found to be only 32.86 per cent. All this is clearly shown

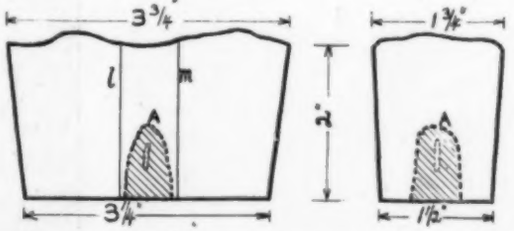


FIG. 3.—TEST INGOT.

in Fig. 3, where the shaded portion A is the ferro. Photomicrograph 2, taken near the apex A, shows the contact line.

The ferro used in this experiment had been chipped from a lump weighing about ten pounds. This lump was now broken wholly into fragments, a number of which were selected at random for the preparation of further pyramids, while the remainder were crushed down for analytical purposes; and, with the light so far vouchsafed, a series of four tests was prepared from the same number of heats of rail-steel, and as many pyramids from the original lump of ferro.

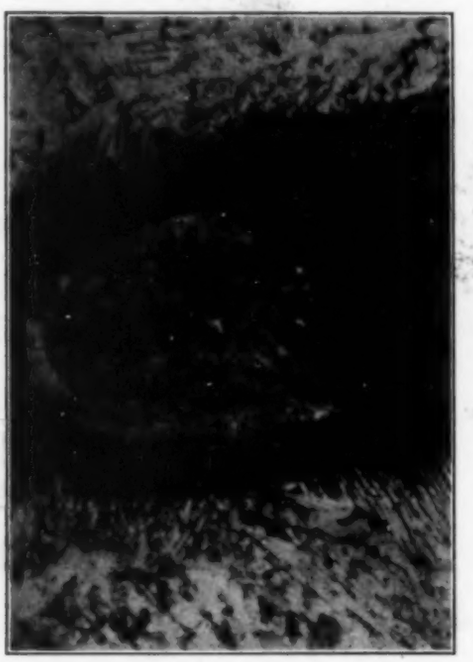
In each case, the regular ladle test—which was taken immediately before our special manganese test—was preserved for comparative examination. Each manganese test was now opened up in the manner described above. A section showing the dividing line between ferro and steel was prepared for

microscopic examination; a portion of the altered ferro was carefully isolated for analysis, and, to be same end, drillings of the steel were taken, as close as might be to the dividing line. The corresponding ladle test was sawn in two, and drillings taken from a corresponding point therein.

A synopsis of the analytical results from this series appears in table III, in which the heats have been arbitrarily numbered 20, 21, 22 and 23. In the steel-analysis columns, A refers to the drillings from the regular test, and B to those from the special test. (See Table III on page 285.)

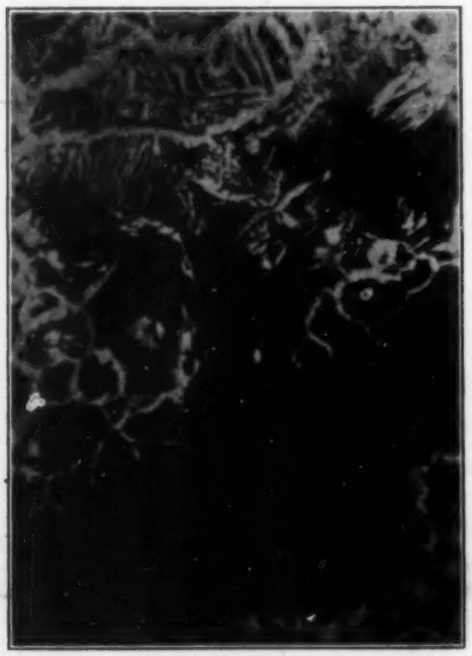
For a reason which will appear, we shall for the moment consider only heats No. 20, 21 and 22.

NO. 3 × 100 D.



NO. 4 × 100 D.

NO. 5 × 100 D.



NO. 6 × 100 D.

MICROPHOTOGRAPHS NOS. 3, 4, 5 AND 6.

These all faithfully reproduced the features of Fig. 3, already outlined, for the first experiment, viz., 1, the base of the pyramid was always unaltered—a natural consequence of the chilling effect of the mold; 2, the upper and greater part of the pyramid had increased in bulk; 3, it had maintained at all points the sharp division between itself and the steel.

Photomicrograph 3 of a section from the apex of the pyramid in heat No. 20 may be considered, equally with No. 2 as generally typical of all three.

Small, centrally located blowholes were always in evidence—either one vermiform cavity, or a row of spherical ones. In addition to these characteristics, the hacksaw was stopped in nearly every cut by globules of the manganese alloy, that had evidently been thrown off from the main body. These globules, or shot, were quite distinct from the steel, and were all found within 1 cm. of the skin of the top and sides of the ingot.

In view of the great degree of similarity exhibited by the three heats, both in their physical features and in their chemical histories, it will simplify matters, without being in any way misleading, to consider an average of the values recorded for them in Table III.

It is obvious that the composition of the ferro has in every case undergone grave alteration, and that in the same direction. It is equally obvious that under the conditions of the experiments, this alteration must have come about in one of three ways, viz., 1, by the outward migration of carbon, phosphorous and manganese from ferro to steel without any immigration of iron from steel to ferro; 2, by emigration of carbon, phosphorus and manganese, with simultaneous immigration of iron; 3, by an immigration of iron from steel to ferro unaccompanied by any passage of carbon, phosphorus or manganese in the opposite direction, i. e., from ferro to steel.

Case I.—Emigration only. Let us assume that on coming in contact with the walls of the mold, the steel chills to a depth of 0.4 cm.—a figure which will be quite near the truth—before the ferro becomes molten and active. This gives us a skull, weighing about 450 g., which can take no part in any mold

TABLE III.

Heat number.	Weight of test.	Weight of Ferro.	Altered Ferro. Total C.	Altered Ferro. P.	Altered Ferro. Mn.	Steel, center drillings.	C.	P.	Mn.
20	1180 g.	20.4 g.	3.41	.178	37.45	A....	.57	.039	.89
						B....	.57	.040	.93
21	995 g.	19.5 g.	3.69	.172	43.28	A....	.63	.043	1.03
						B....	.62	.043	1.08
22	1370 g.	31.5 g.	4.42	.186	49.44	A....	.67	.032	.85
						B....	.62	.028	1.07
Average of 20, 21 & 22	1182 g.	23.8 g.	3.84	.179	43.39	A....	.62	.038	.92
						B....	.60	.037	1.03
23	1120 g.	13.8 g.	...	...	....	A....	.54	.040	.92
						B1...	.58	...	1.01
						B2...	.59	...	1.01
Original Ferro.....			6.45	.288	77.72				

reaction. Five grams would be a liberal estimate of the amount of ferro remaining unaltered in the base of the pyramid.

Now, considering for convenience that the ferro consists only of carbon, iron and manganese, at the beginning of the mold reaction we have: skull, 450.0 g.; active ferro, 18.8 g.; active steel, 713.2 g.

At the end of the reaction we should have our 450.0 g. of unaltered steel, a very small bulk of altered ferro—about 5.6 g.—and the balance of the test would be steel, enriched in carbon and manganese to the extent of .14 and 1.70 per cent respectively, which enrichment, plus the original content, would yield a steel containing .76 per cent of carbon, and 2.64 per cent of manganese. Case I evidently does not apply.

Case II.—Emigration and Immigration. In our experiments, the ferro-manganese, once it has attained the temperature of the molten steel is, on account of its lower melting point (see Table IV), characterized by greater mobility than the latter. Its molecules are more active than are those of the steel. Before the ferro has reached this stage, there is a period during which the steel will have the advantage in this respect; but it is probable that such period is of relatively short duration; and, upon the whole, from this point of view, it would be expected that the outward travel of the carbon, phosphorus and manganese would proceed more rapidly than the passage of the iron inwards. Let us suppose, however, that the rate of travel is the same for all the elements in both directions.

We find, following the line of calculation employed in Case I., that we should have left an altered pyramid of approximately the same weight as the one we started out with, and a matrix of steel enriched to 0.69 per cent of carbon and 1.82 per cent of manganese. No such enrichment has occurred. It appears that the average B carbon is actually slightly lower than the A carbon, and that the manganese figures in 20 B and 21 B are only 0.04 and 0.05 per cent greater, respectively, than the A values. Indeed it is only the general trend of the average that entitles these small majorities to consideration.

Case III.—Here we look upon the alteration that has taken place in the ferro as a simple process of dilution; and we shall expect to find: 1, That the pyramid has increased in bulk; 2, that the surrounding steel, other causes apart, has suffered no chemical alteration other than a slight concentration due to loss of iron; 3, that the ratio of percentage in altered ferro to percentage in original ferro is the same for all the elements except iron. The ratios in the present case, calculated from the averages in Table III are: For carbon, 0.595; for phosphorus, 0.621; and for manganese, 0.558. In each of these three respects, Case III appears to fit the observed facts with remarkable closeness. The slight discrepancies find their explanation in what follows.

The evidence so far in hand would lead, therefore, to the supposition that when molten ferro comes in contact with molten steel, there sets in, from steel to ferro, a migration of iron molecules which continues, if uninterrupted by solidification, until both metals are of the same composition, and that then, and only then, merging of the two is effected and the dividing line disappears, though it may become imperceptible by any means at our disposal, before this stage has actually been reached.

It has been remarked that in our tests, globules were thrown off from the main body of ferro. There were probably many more of these little planets than chanced to be in the path of the saw in the particular cuts that were made. It is also exceedingly likely that some of the globules were so tiny that they were speedily reduced to the composition of the surrounding steel, becoming a part of the latter and raising its manganese content.

This would account for the few points of increase in the B lines of Table III. No one who is in the least familiar with the idiosyncrasies of steel ingots—large or small—will invest with significance the trifling carbon discrepancies noticeable in the steel figures in this table.

Further, at any instant in such a process of "infusion" as we are picturing, the outer skin of the pyramid contains more iron than the central portions. In order, therefore, to get a perfectly "sound" sample of the altered pyramid for analysis, it would be essential to secure every particle of it, reduce it to fine powder and mix it thoroughly. In point of fact one considered oneself fortunate if one managed safely to isolate barely enough for the necessary determinations.

Moreover, the material is to a certain extent malleable, and cannot be puverized nor mixed at all thoroughly; so that, in view of everything, the figures for the carbon, phosphorus and manganese ratios, given above, are really wonderfully close, and may safely be considered to represent the same value.

As has already been implied, heat No. 23 behaved differently from the others. In this case, the pyramid of ferro was raised bodily by the incoming stream of steel, floated immediately up to the surface of the test and, melting, spread over the entire top as a crust, quite distinct from the steel, and visible as such in the cold ingot, in which also were embedded a number of distinct globules just beneath the crust. Analyses 23 B 1 and 23 B 2—Table III—are of drillings taken from the steel in the neighborhood of the globules, and from the heart of the test, respectively. These figures are readily explained by which has been said of heats 20, 21 and 22.

It will be convenient at this stage to set down such melting points of iron—manganese alloys, with or without carbon, as are at present available to the writer. They are introduced—without comment—along with certain other melting points which have a bearing on the matter in hand.

TABLE IV.

	Total C.	Comb. C.	Graph. C.	Si.	S.	P.	Mn.	Fe.	Solid. Pt. deg.C.	Melt'g Pt. deg.C.
Ferromang[1]	.. ....	5.10	...	.71	.65	...	80.96	13.16	1210	...
" " [1]	.. ....	5.00	...	.43	..	.11	48.95	45.51	1145	....
" " [1]	.. ....	4.80	...	.80	..	.098	16.97	77.51	1083	....
" " [2]	.. ....	6.56	.120	.56	tr.	.300	82.36	10.00	1230	....
Alloys of a 99.74 p. c. pure iron with a 99.4 p. c. pure Manganese[3]	...	...	...	...	..	...	10.00	....	....	1525
	...	...	...	...	..	...	20.00	....	....	1483
	...	...	...	...	..	...	30.00	....	....	1442
	...	...	...	...	..	...	40.00	....	....	1380
	...	...	...	...	..	...	50.00	....	....	1340
	...	...	...	...	..	...	60.00	....	....	1288
	...	...	...	...	..	...	70.00	....	....	1275
	...	...	...	...	..	...	80.00	....	....	1260
	...	...	...	...	..	...	90.00	....	....	1250
	...	...	...	...	..	...	99.40	....	....	1245
White iron[4]	.. ....	3.85	tr.	.29	.03	.02	.15	....	1030	1065
Gray iron[5]	....3.50	...	...	1.75	..	.50	....	....	....	1220
Soft steel[6]	... .	.10	...	...	..	...	.30	....	....	1475
Hard steel[6]	.. ....	.90	...	...	..	...	.10	....	....	1410

[1] Jour. Iron & Steel Inst. 1900 II 343, from Osmond & Werth, Ann. des Mines, July-Aug., 1888.
[2] Roberts & Wraight, Jour. Iron & Steel Inst. 1906 II 235.
[3] This Journal, IV, 190, from Levin & Tamman, Metallurgie, Jan. 22, 1906.
[4] Royston, Jour. Iron & Steel Inst., 1897 I 167.
[5] Hofman, "Iron & Steel," from Le Chatelier, Comptes Rendus CXL 471.
[6] Cremer & Bicknell, from Le Chatelier.

The whole process of infusion, as we have portrayed it, must be conceived to be quite rapid, inasmuch as the phenomena described have occupied only the few moments elapsing between the pouring of the test and its solidification. We have seen that when thermit was used, the reaction, always supposing it to have been of the same nature, was practically instantaneous, on account, doubtless, of the very high temperature of the

thermit iron. It was anticipated that by repeating the pyramid test with soft steel instead of rail steel, an intermediate stage might be arrived at.

Two such tests were accordingly poured, which we shall call heats 24 and 25. Heat 24 developed the structure shown in Fig. 4. Where the pyramid had been, appeared a cavity, considerably larger than the pyramid, opening on the bottom of the test. This cavity, A, Fig. 4, is enveloped by a distinct sac of manganese alloy—shown in the drawing by dotted lines —which was found by analysis to contain 26.30 per cent of manganese.

Almost the entire upper part of the ingot is occupied by one large cavity, B, Fig. 4, which, like A, is enveloped by a

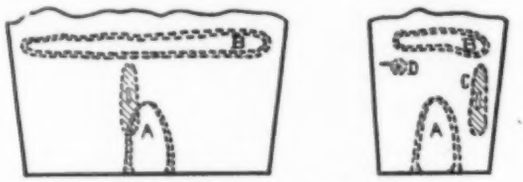


FIG. 4.—STRUCTURE OF HEAT 24.

distinct manganese sac. A portion of the B wall was found to contain 34.33 per cent Mn; but it should be mentioned that the B sample was rather a globule adherent to the sac wall, than a part of the wall proper, and that this doubtless accounts for the higher Mn content. We should naturally expect the B wall to have undergone more alteration than the A wall.

Unfortunately, the difficulty of separating the thinner portions of the alloy from adherent steel prevented a more exhaustive examination. It was readily notable, that the walls of A and B exhibited none of the superficial characteristics of ordinary blowholes, but answered exactly to the description given above for A, Fig. 2.

Besides A and B, there appeared at C, Fig. 4, a lenticular body of manganese alloy parallel to the skin of the ingot, and about 0.5 cm. away from it, which offshoot showed at its center, a small vermiform cavity similar to the one seen in A, Fig. 3.

Several globules were also found at various points, but always next to the skin. One of these is sketched at D, Fig. 4. The

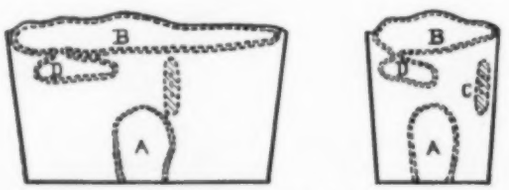


FIG. 5.—HEAT 25.

small spur attached to this globule is the subject of photomicrograph 4, of which more anon. Center drillings of the steel from the regular ladle test and from the pyramid test of heat No. 24 showed:

Heat No. 24	C.	P.	Mn.
Regular test	.18	.043	.36
Pyramid test	.20	.044	.36

The internal arrangement of the ingot obtained from heat No. 25, is sketched in Fig. 5, and closely resembles No. 24 in every particular, except that in Fig. 5 the upper wall of B constitutes the top crust of the ingot. Further, this wall is extended downwards to cover a short canal, and a third blowhole D, to which the canal leads up. Shot are also freely in evidence.

In this instance no reliable drillings could be obtained from the steel, because of the proximity to one another of A, B, and D, and because of the shot. Also the sac walls were too thin to isolate satisfactorily.

The last two experiments thus not only confirm in every way our former deductions, but shed light on the formation of the blowhole in the original roll. It would appear that a part of the gases that are commonly in solution or combination in molten steel, has migrated with the iron molecules into the manganiferous body. Their tendency in this direction was foreshadowed by the small blowholes observed in the centers of the first four pyramids, but has only been convincingly demonstrated in the last two cases, doubtless in some measure on account of the higher gaseous content of soft steel, as well as because of the higher temperature.

This, then, is probably what occurs when soft steel is poured upon a fragment of ferro manganese—the ferro fuses, and an influx of iron and gas molecules promptly sets in from all sides. The gas, when it reaches the molten ferro, is thrown out of solution because of the notably lower solvent power of the manganese alloy for gases.

Such oxygen as may be present combines with the carbon of the ferro, forming CO. The pyramid, perforce, increases in size. In the meantime its extreme outside layer, on account of its higher iron content, is at any moment nearer its solidifying point than the interior, and, as cooling and dilution progress, the pyramid presently becomes a cyst, with a more or less rigid envelope, and a fluid interior.

At this stage, the envelope cannot expand rapidly enough to meet the demands of its ever-increasing gaseous and liquid contents, which finally rupture their sac at the apex, which is the hottest and weakest point. This breakout is also assisted by the relatively higher mobility and lower gravity of the sac contents, which by virtue of these attributes take an outward and upward direction and rush to the top and sides of the ingot, arranging themselves parallel, as to their long axes, to the cooling surface.

The portions which station themselves at the sides are soon imprisoned in the cooling steel and rendered inactive. The main body, however, locates itself in the middle top of the ingot, which, being the last to solidify, affords ample time to its tenant for the reception of iron and gas molecules from the surrounding mass. The resulting bubble, finding no weak spots to break through, expands in loco till checked by solidification.

(*To be concluded.*)

Thermit

We have referred before to the injurious influences of nitrogen on iron and steel and the possibility of removing nitrogen from steel by introducing titanium into the ladle. In No. 2 of *Reactions*, published by the Goldschmidt Thermit Co., the following analyses are given on the effect of the titanium thermit reaction on the sulphur content; they also show that only traces of the titanium were absorbed by the metal:

Cast iron before treatment, 0.36 Mn, 0.19 S; after treatment, 0.30 Mn, 0.09 S, traces Ti. Another analysis gave before treatment, 0.66 Mn, 0.09 S; after treatment, 0.64 Mn, 0.07 S, traces Ti.

Results of mechanical tests are also given, showing the increase in strength of metal treated with titanium thermit.

Besides the very interesting article of Dr. Hans Goldschmidt on calcium silicide, a purifier for steel (published in our last issue, page 244) the same issue of *Reactions* contains illustrated articles on the welding of rails under New York City traffic conditions, pipe welding experiences, various thermit repairs, etc.

An article by Mr. G. E. Pellisier discusses blow-holes in thermit welds, their cause and prevention and shows that the secret of success lies in proper preheating of the pieces to be welded. "The secret of success is to have the parts to be welded at a bright red heat, when the thermit steel is poured, provide a good sink head, have the thermit and additions thoroughly mixed and take care not to tap the crucible until the reaction is thoroughly completed."

Separating Appliances—II.

BY OSKAR NAGEL, PH.D.

Presses.

Another appliance for separating solids from liquids by means of pressure is the press.

The simplest type which can be used for this purpose is the screw press (Fig. 1). The material to be dried is filled into bags or wrapped up in cloths and then put into the press. The various bags, etc., are separated from each other by means of metallic or wooden plates.

FIG. 1.—SCREW PRESS.

For chemical works the hydraulic presses are of greatest importance, since their requirements as to power and attendance are small.

The construction of the hydraulic press is based upon the principle of the uniformity of pressure in liquids contained in closed vessels. The press consists of two separate parts—the press proper and the press pump. The press proper is illustrated in Fig. 2, showing the press plate, the piston moving in its cylinder, the head-plate, and the columns connecting the base with the head-plate.

The press pump is a plunger pump provided with automatic relief set to a certain pressure, which naturally varies according to the nature of the material to be pressed.

The pressure produced by the press pump is transmitted from the liquid of the pump (water, glycerine or a mixture of both)

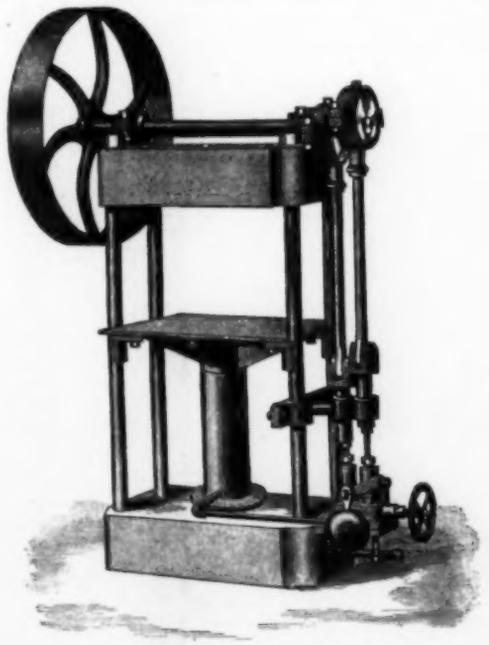


FIG. 2.—HYDRAULIC PRESS.

to the liquid in the cylinder of the press, whereby the same pressure is exerted upon the unit of area of the piston of the press, as upon the unit of area of the piston of the pump.

The material to be pressed is handled in the same manner as with a screw press. If the pressing is to be performed at a high temperature, the plates separating the layers (cakes) have to be heated by steam. One press pump is sufficient for several presses.

Hydraulic presses are built by the Watson-Stillman Co., New York; R. D. Wood & Co., Philadelphia, and The Hydraulic Press Manufacturing Co., Mt. Gilead, Ohio.

Other Filtering Appliances.

For filtering thick and pastry masses, vacuum filters (Fig. 3) are used, the vacuum being produced by means of a steam jet blower or a vacuum pump. For acids these apparatus are made of lead or of clay.

M. Garros recommends asbestos-porcelain as filtering mass for strong acids. This material is prepared by grinding asbestos to a fine powder and washing the latter first with muriatic acid and then with pure water. The plastic mass so obtained is burned at about 1600° C. and shows after cooling such fine pores that it can be used successfully as filtering material.

FIG. 3.—VACUUM FILTER.

Another method of separating solids and liquids is the application of sand and other filters. For this purpose basins are built in which layers of pebble, gravel and sand are provided, the latter being supported by perforated plates. The water so to be filtered enters on top, flows through the three layers and finally reaches, in a pure state, the pipe line provided below the perforated plates.

The operation of these filters is rather slow, gravity being the only acting force. If a quicker method is desired, pressure has to be applied. Such pressure filters will be described in an article on the purification of boiler water.

If the water is only cloudy and its filtration meets with great difficulties the following device is to be recommended (Fig. 4).

The reservoir H contains the water to be filtered; tank M contains a thin pulp of cellulose or fibrous asbestos with water.

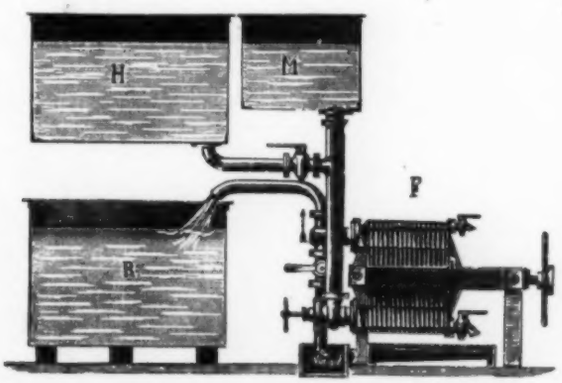


FIG. 4.—FILTERING DEVICE.

F is the filtering apparatus proper and the purified water runs off into R. F is built like a filterpress and contains a number of chambers, the walls being formed by metallic sieves.

At first the thin pulp or paste is passed (from M) into the filter F, where it is uniformly divided. The arrangement is somewhat similar to the three-chamber press mentioned in a previous article. The water from H is then allowed to run through this filtering mass and flows into tank R. When the filtering mass becomes inactive, it has so to be removed and washed, before being put to use again.

For the treatment of slimes the filters built by the Blaisdell Company, of Los Angeles, Cal.; The Kelly Filter Press Co., of Salt Lake City, Utah, and The Butters Patent Vacuum Filter Company, Inc., of San Francisco, Cal., are used.

The Blaidsdell pressure filter (Fig. 5 and 6) contains a series of filter leaves, depending in number and size upon the capacity desired; a pressure cylinder and pumps for vacuum, slimes, water and solution, with pipes and valves.

With a pressure of 25 to 50 pounds per square inch in the pressure cylinder, the clear water or solution is rapidly forced into the interior of the filter leaves, and out through the discharge pipes to the water or solution tanks, the slime remaining as a cake on the outside of the filter leaves.

This process is continuous and is carried on without interrupting the flow of slime to the pressure cylinder. As soon as a cake of sufficient thickness is formed, clear water under a greater pressure than exists within the cylinder is admitted to the interior of the leaves in groups. This excess of pressure causes the cake on that particular group of leaves to fall through the slime to the bottom of the cylinder. The thickened material accumulating on the bottom of the cylinder is discharged from time to time.

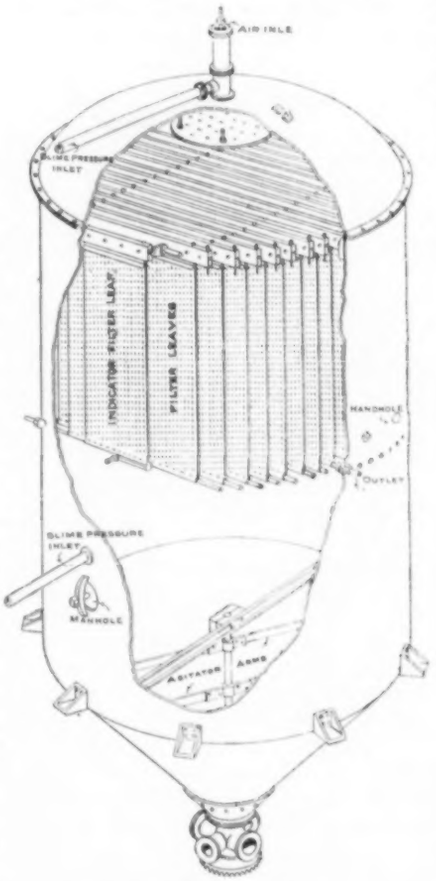


FIG. 5.—PRESSURE FILTER.

The Kelly filter (Fig. 7) consists of a tank in which a carriage runs on tracks carrying the filters. Whenever the filters are heavily charged with separated solid material, and it is desired to remove the collected solid material from the sides of the filter frames, the carriage is run out of the tank on to an exterior trackway. (See also this journal, Vol. V, p. 508, and Vol. VI, p. 163.)

The Butters filter was described in detail in the March issue of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Vol. V. p. 88. (See also the account of a recent patent of Mr. Butters, this journal, Vol. VI, p. 120.)

Separation by Crystallization, Extraction and Sublimation.

Crystallization.—For separating a dissolved salt from its solvent or from a mixed solution, various methods can be used. If the substances have the property of being precipitated by concentration—soda, etc.—the solutions are evaporated and the separating crystals are continuously removed, for which purpose the Thelenpan, which will be described in another article, is exceedingly well adapted.

There are cases (Glauber's salt, etc.) where no direct precipitate is obtained during evaporation, but where it is necessary to cool the solution. The solid substances are then allowed to separate by crystallization in suitable vessels.

For effecting a uniform crystallization throughout the liquor, hooks made of steel or copper wire are suspended into the same, by means of which the crystals can be easily lifted out of the liquor.

If no hooks are used, the crystals formed fall to the bottom and the mother-lye has then to be syphoned off. If crystals

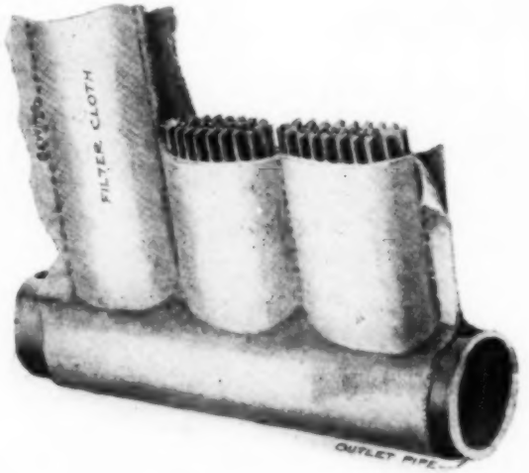


FIG. 6.—PRESSURE FILTER.

deposit on the walls of the vessel, they can be knocked off and removed by means of perforated spoons. Or, perforated pots are put into the vessel and the mother-lye entering the pots is syphoned off.

Extraction is used for separating the soluble components from a partly soluble substance. The high pressure frequently applied during extraction is produced by either steam or compressed air, depending upon the nature of the material to be treated.

FIG. 7.—FILTER PRESS.

An extractor for dyewood, tanbark, etc., is shown in Fig. 8. The extractor is a vertical cylinder, provided with a charging and discharging opening, water and steam inlet and solution outlet. The armature consists of a manometer, thermometer and two test cocks.

If several of these apparatus are connected to a battery the connection is made in such a manner (see Fig. 8) that the final

solution of the first apparatus is utilized for eluting the fresh charge of the second apparatus, whereby the concentration of the solutions is increased. The apparatus to be discharged first gets the fresh water, while the more concentrated solution is taken from the apparatus charged with fresh material.

An apparatus for extracting at high temperature and ordinary pressure fats, oils, rosins, etc., by using benzine, bisulphide of

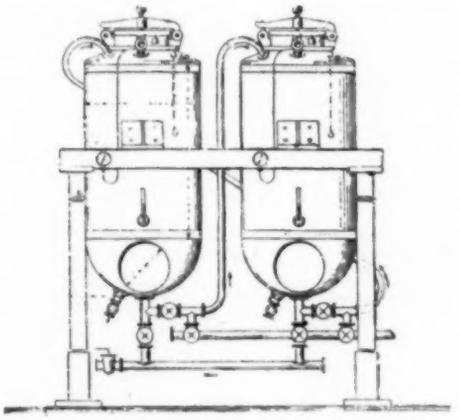


FIG. 8.—EXTRACTOR.

carbon, alcohol, etc., as solvents, is built by Josef Merz in Brünn (Austria).

The vessel C (Fig. 9) contains at the bottom a steam coil Q, and above it a reservoir L, which is charged through the manhole *d* with the material to be extracted. From the reservoir V, which is combined with the cooler R, the solvent is allowed to flow into L. As soon as the level of the solvent exceeds the

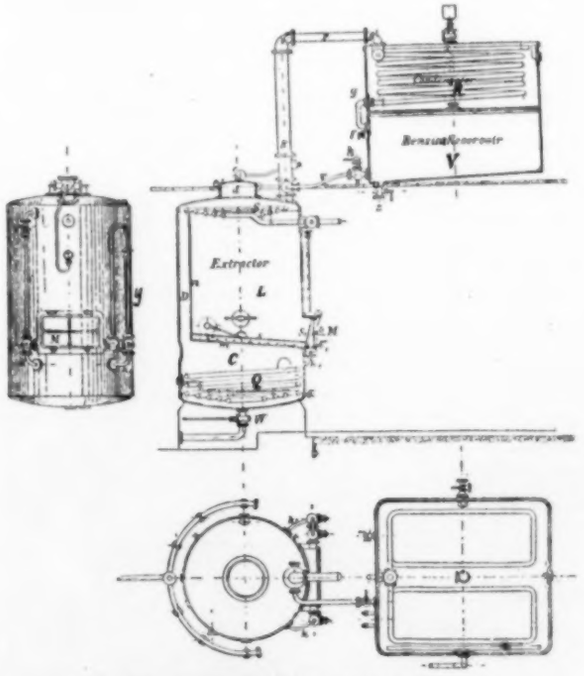


FIG. 9.—EXTRACTION APPARATUS.

height of syphon *y*, it is drawn into C. In C the solution is evaporated, the vapors rise along the wall of reservoir L, heating its content and finally arrive at coil S, where they are condensed. The warm liquid "rains" back into L and after rising to the height of the syphon, again goes into C.

This automatic circulation is interrupted, when a sample taken as M shows that the extraction is finished. The cooling water (in S) is stopped, the vapors of the solution flowing from L into C travel to cooler R and are collected as liquid in reservoir V. The last traces of the solvent are removed from the extract and the spens material by means of direct steam.

The extract is discharged through W and the extractor L at M. This apparatus permits intermittent and continuous ex-

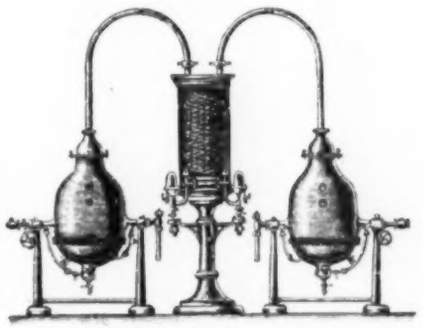


FIG. 10.—EXTRACTION APPARATUS.

traction. In the latter case the flow of the fat-solution is so regulated that the level of liquid in L is kept constant by the evaporated and regenerated solvent.

This universal extractor affords perfect safety against ignition and explosion, insuring a minimum consumption of the solvent, simple and economical operation and absence of odors.

A twin apparatus for extracting etheric oils is shown in Fig. 10. It consists of two stills which can be heated by leading steam into the "false bottom" or by direct steam led into the interior of the apparatus. The solid substances to be treated in the extraction apparatus rest upon a perforated plate.

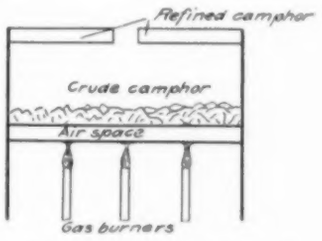


FIG. 11.—REFINING CAMPHOR.

After charging the apparatus with the solid substances and the extracting liquid, the steam valve is opened, whereby the extracting liquid is vaporized. This vapor travels through the substance, rises upward along the dissolved components and enters the cooler. When leaving the cooler it is tested as to its "extract" contents, and recharged until it shows the concentration required.

Sublimation.—This process, in which gaseous distillates are directly solidified without passing through the liquid stage, is employed in the case of iodine, salammoniac and camphor. Fig. 11 shows a simple apparatus for subliming camphor. The refined camphor forms a solid cake at the top of the vessel, while the impurities remain as a residue on the bottom.

Separation by Settling and Freezing.

Liquids of different specific gravity which do not mix can be separated by allowing the heavier liquid to settle. The apparatus (Fig. 12) has near the bottom an opening, to which an S-shaped overflow pipe is connected. If a layer of oil is floating upon the water, only the water will flow through this pipe. It the oil is to be collected the water is let off until its surface is on the same level as the cock at the left side. Then the oil is allowed to run off through the cock.

Sometimes liquids are separated by cooling and removing the frozen part from the liquid (Lunge's monohydrate process).

Separation by evaporation and distillation will be described in another article.

Mechanical Separation of Solids.

The separation of substances according to their size ("sizing") is a matter of great importance in metallurgy and is generally performed by means of screens.

Fig. 13 shows an arrangement of three revolving screens, in which either perforated metal or wire cloth may be used. Bevel gearing is shown driving the first screen, which communicates motion by spur wheels to successive screens having finer perforations or meshes, and being placed at lower levels. In concentrating works, sets of four or more such screens are usually employed.

The first screen separates out all pieces too large for the ore treatment processes so that they may be returned to the crushing machinery. The remainder passes through the perforations of the first screen, and is conveyed to the second screen, and so on through the set, each screen furnishing a product sized between the limits of the size of its own perforations and the perforations of the preceding screens.

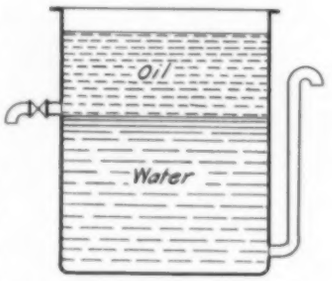


FIG. 12.—SEPARATION OF OIL FROM WATER.

For separating coarse from fine substances without the use of sieves, by means of an air current, "separators" are used.

In the separator of Mumfors and Moodie (Fig. 14) a ventilator E is provided upon the vertical shaft E_2. The latter carries also the distributing plate S, the object of which, as the name implies, is to distribute over its periphery the material to be separated. By a system of rings, disks and cones the air drawn in by the ventilator is forced through the material which is constantly falling down in the shape of a bell. The air current carries the fine, dusty particles along and enters the ventilator, the mixture being thrown against the wall of the cylindrical tank A. The fine particles are carried to the bottom by the air current. The coarse parts not carried along by the air current fall into the interior cone B and may be retransported to the mill (through pipe *a*), while the separated fine product falls into the space between housing A and cone B and is removed from here by hand or a screw conveyor.

The jigs and magnetic separators will be described in another article.

Foundrymen's Convention.—The convention of the American Foundrymen's Association and its associated societies, held in Toronto, Canada, from June 8 to 12, proved a success beyond all expectations. The registration on the last day passed the 1,400 mark. The exhibition was exceedingly well arranged, and the papers presented elicited very interesting discussions. On account of limitations of space we must reserve a fuller report for out next issue. Mr. L. L. Anthes, of the Toronto Foundry Co., is the new president. Dr. Richard Moldenke remains the ever-active secretary of the association. The next meeting will be held in Cincinnati.

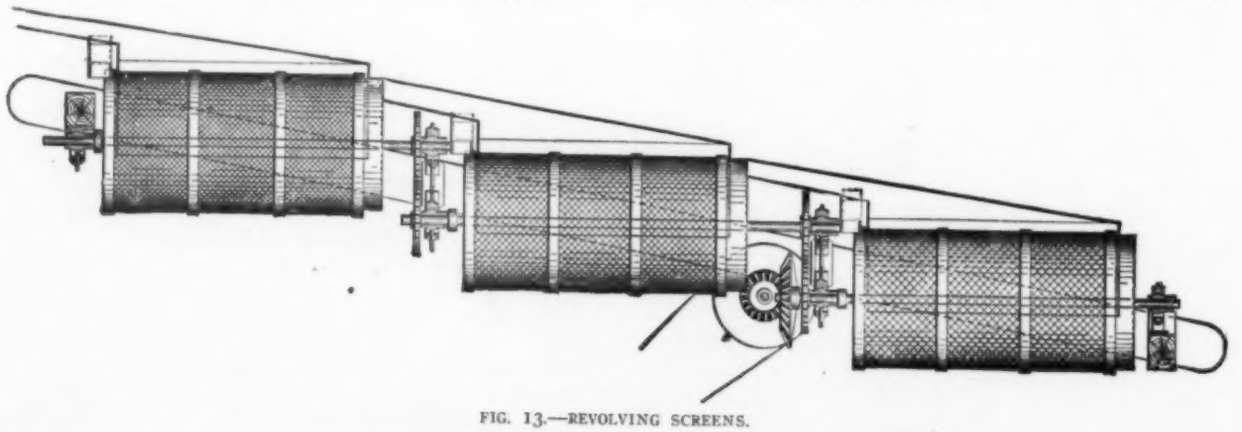


FIG. 13.—REVOLVING SCREENS.

Annual Meeting of the Iron and Steel Institute.

The thirty-ninth annual general meeting of the Iron and Steel Institute was held in London on May 14 and 15, the president, Sir Hugh Bell, being in charge.

From the report of the council it may be mentioned that the total membership has increased from 1500 in 1898 to 2100 in 1908. The Bessemer gold medal was presented this year to Mr. Benjamin Talbot, Middlesborough, while the Carnegie gold medal for research was awarded to Dr. C. A. F. Benedicks, of the University of Upsala, Sweden.

In the following we give abstracts of the progress presented at the meeting:

Cast Iron in Chemical Plant.

A paper by Mr. T. J. R. Carulla (Derby) discusses the use of cast iron in the construction of chemical plant.

Wrought iron and its modern substitute, mild steel, do not need lengthy attention. The use made of the material for gas holders and similar vessels need not be dwelt upon, and its value for bolts, bands, stays and beams, when these can be painted or tarred to prevent corrosion, cannot be overlooked.

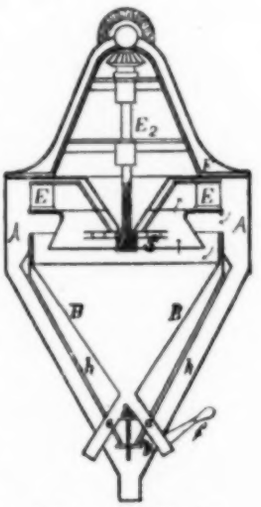


FIG. 14.—SEPARATOR.

But here the surprising thing happens, that although so easily corroded, tanks can be made of this material that will carry strong sulphuric acid for years without damage being done to them. The only care necessary is that no water be admitted into the tank after use, when, of course, if left in, a weak acid solution would be formed and rapid corrosion ensue. Inattention to this requirement will certainly cause the destruction of a tank.

Cast iron, the main object of the paper of Mr. Carulla, furnishes a substance that the chemical manufacturer could ill afford to be without, but which, in consequence of its varied composition and uncertain properties, is most difficult to classify. The consequence is that there are firms who possess experience and special knowledge of the use of particular brands for certain purposes that are unknown to the trade in general. Nevertheless, some simple rules can be applied even in this case.

For some purposes, as, for example, ammonia stills, cast iron seems everlasting, and there can be no secret as to brands. One such apparatus, known to the author, is as perfect to-day as when it was erected 18 years ago, at any rate the cast iron part of it. There is no sign of wear in any of the

numerous cylinders; indeed, a remarkable thing was that the lower section of the line cylinders and the most important, as it has the manhole, leaked at the very start, a considerable blowhole making itself evident in the casting. Although the makers, with a full sense of justice, sent a new section to replace the faulty one, as the sill was up, operations were started, making good the bad place with rust cement (iron filings and salammoniac). Notwithstanding that the work carried on at a pressure of 8 to 10 lb. per square inch, the place has not leaked since.

In the case of ammonia stills the reactions are entirely basic, lime being used to drive away the fixed portion of the volatile alkali, but even acid chemicals have sometimes little action on cast iron. It is wonderful to see the length of time that a nitre pot made of this material will withstand the action of sulphuric and nitrous acids in a glowing furnace, the seething mass taking months and sometimes years to destroy the vessel. Yet when hydrochloric acid is in question cast iron succumbs like any weaker metal.

But while this is common knowledge the fact is not realized to its full extent. Percy ("Iron and Steel," page 145) describes the experiments* of Daniell, who obtained from a cube of cast iron, immersed in dilute hydrochloric acid, a spongy mass, easily cut with a knife, which was dark gray, somewhat resembling plumbago. He further gives Calvert's analysis of such a residue produced by the uninterrupted action of the acid during two years on cubes of the metal. Then he goes on to tell us of the similar action of seawater on cast-iron guns got out of an armed vessel that 50 years before had sunk near Carlscrona, which were found to be changed to the extent of one-third into a gray porous graphitic mass. Finally, Percy repeats the well-known instance of the guns, also of cast iron, raised from the *Florida*, one of the vessels belonging to the Spanish armada, which was sunk off the coast of Mull, in Scotland, and when brought up the graphitic mass into which they had been converted became so hot that it could not be touched.

These accounts, spread over such long periods, are little calculated to impress one with the violent and rapid manner in which the action may take place. The author found that the plug of a cast-iron cock, used to keep back ferrous liquor containing a very small percentage of free hydrochloric acid, was acted upon to the depth of one-eighth of an inch in a few months. This discovery was most opportune, for it caused the examination of a cast-iron vessel of considerable size into which the liquor in question was admitted, and a similar action was found to be going on. It was fortunate that this was perceived at so early a stage, for as little damage had been done, by a variation of the process that is in no way detrimental the action has been arrested, while the vessel is still good. Ammonia has to be used in the process, and a portion being put in at an earlier stage the acidity of the liquor and its injurious power are completely destroyed.

It is evident that this action of hydrochloric acid is one to be most carefully guarded against. Both the user and the maker of vessels that have to endure it are interested in the matter. Here then comes a distinction.

Cast iron is divided into two main groups, the white and the gray irons. The experiments of Prof. Daniell, already referred to, show that gray iron is more rapidly attacked than the white—three times as fast. Hence, if a cast-iron vessel is required to resist the action of hydrochloric acid it is reasonable to say that white iron should be selected. But other conditions may have to enter into one's calculation, and if the vessel has to resist internal pressure, as is often necessary, the tougher gray iron is preferable to the white and brittle. The iron-founder is, therefore, placed between the horns of a dilemma, and the natural way to get out of the difficulty is to make a mixture of white and gray brand, the gray giving the tenacity and the white the acid-resisting power.

This, however, would not be so good as to cast around collapsible chills with gray iron, when the interior of the casting, assumed to be cylindrical, becoming white iron to a certain depth, would offer the required chemical resistance, while the outer coat of considerable thickness, remaining gray, would give the necessary tenacity. Vessels for chemical operations could certainly be produced on this plan, if it has not already been done.

In connection with the action of hydrochloric acid there are operations in which not only the unexpected, but the unsuspected may happen. Hydrochloric acid in its free state, and especially in its weak state, one knows that he must guard against, but chlorides seem so innocent that one is apt to overlook them. Now, ammonium chloride raised to 300° C. becomes dissociated, the hydrochloric acid being thus set free, what wonder, then, that the iron tar stills (Davis, Handbook of Chemical Engineering, 1901, vol. II, p. 260), which are heated to the melting point of lead (325° C.) are affected by the ammonium chloride that has not been separated from the raw tar?

Another point which it is important to note, and which is frequently overlooked, is that of not using wrough.-iron chaplets to hold up the cores of pipes, etc., that are to be employed for chemical work. Failures are certain in such cases when the chemical has any action on iron, for the comparatively pure metal is more readily attacked than the cast iron. Even when cast-iron supports are used, failures may result, as the fusing together with the main casting may not be complete. The method of casting pipes vertically without the use of chaplets is, hence, to be recommended for chemical work.

The discussion on Mr. F. J. R. CARULLA's paper on "Cast Iron in the Construction of Chemical Plants" was begun by Prof. Turner, who remarked that alkaline hydroxides protected cast iron from rust, but it was not so well known that very weak acids—even dilute acetic acid—gradually dissolved iron leaving a graphitic residue of the original form. All varieties of cast iron were attacked by hydrochloric acid. Experiment showed that cast iron containing as much as 10 to 15 per cent of silicon was insidiously attacked. Nitre pots varied considerably in regard to the rate at which they were acted on. His experience was that with close-grained iron containing little phosphorus, like old Staffordshire iron, the action was reduced.

Mr. Harbord expressed his preference for white iron for tanks used for boiling sulphuric acid. Castings in white iron were not easily obtainable, but he knew of one case where they were made for dealing with boiling sulphuric acid.

Mr. Stead pointed out that strong sulphuric acid did not appreciably attack iron because ferrous sulphate is insoluble in concentrated sulphuric acid, but hydrochloric acid produced a soluble chloride with consequent continual exposure of fresh surfaces of metal to its action. The difference between white and gray iron in resisting the action of acids was due to the graphitic carbon in the latter forming couples with the iron, the action was inversely as the proportion of carbide in the metal. Steam sometimes, but not invariably, produced a gray film on cast iron. A specimen of high-silicon iron had been in his laboratory for several years without more than superficially tarnishing, and rubbing with a cloth restored its original brightness; but the high-silicon iron is unsuitable for castings by reason of its extreme brittleness.

Mr. Paul referred to a case in which 1 per cent of silicon in thin steel plate gave such trouble in pickling that tinning operations were impracticable.

Prof. Turner suggested that silicon iron might be used in cases where hammering and turning could be dispensed with.

Mr. Carulla then announced that he would publish his reply in the *Journal*, as he had received some communications which he wished to deal with. Aluminium might be advantageously employed instead of iron for operations involving the use of acetic acid. Although high-silicon iron was so brittle, yet it

*Calvert's analyses are given as follows. Cast iron: 95.413 Fe., 2.900 C., 0.790 N., 0.478 Si., 0.170 S., 0.132 P., loss 0.108. Residue: 79.960 Fe., 11.020 C., 2.590 N., 6.070 Si., 0.096 S., 0.059 P., loss 0.205.

might perhaps be used for linings and wrought iron could be employed for the exterior, but if this material would only last twice as long as ordinary iron it would not pay to use it. He thanked Mr. Stead for his remarks on the action of steam, which were new information to him.

The president proposed a vote of thanks, and remarked that the "cussedness" of matter often brought about unexpected results, but that was only equivalent to saying that our knowledge of the physical properties of materials was not so perfect as it was supposed to be. He instanced a case within his own experience in the ammonia-soda process where very dilute solutions caused pipes to constantly become filled with crystalline deposit, which, he facetiously declared, should not have occurred had Nature been properly organized.

Plate Rolling Mills.

A paper by Mr. Andrew Lamberton discussed improvements in plate rolling mills, with special reference to the rolling of thin plates. The three principal conditions which platemakers must fulfil in England are: 1, quality, represented by the usual tensile and bending tests; 2, first-class surface finish throughout; 3, close adherence to gauge thickness. No such stringent conditions are made in the United States either with respect to first-class finish throughout or to close adherence to gauge thickness. While the author says that a margin of 15 per cent variation in thickness is sometimes accepted in the United States, adherence to gauge thickness in England must be generally within 2½ per cent or under.

Were it not for the stringency of these conditions, the probability is that plate rolling-mills of the American three-high type would have been adopted in England before this time. It is unquestionable that for thin plates the three-high mill has some advantages; but, unfortunately, it has the great drawback of being unable to maintain high-surface finish on plates for more than two or three days, when the rolls require to be changed. This defect is inherent in the design of the mill where the roughing-down of the slab and the finishing of the plate are done in one set of rolls, causing rapid deterioration of their surfaces. The usual practice is to use a top roll and a bottom roll of equal diameter with a mid roll of two-thirds their diameter. At every pass of the plate, whether between top and mid, or bottom and mid, the mid roll does work, so that twice the work is put upon it that the top and bottom rolls are required to do, and, as it has only two-thirds of their surface, it wears much more rapidly, the surface becomes quickly injured. This necessitates the changing of the rolls every two or three days, which is a drawback of a very serious nature. To meet this the practice is to roll all plates requiring the highest finish during the first 24 hours' working of the mill and devote the subsequent one of two days' working to plates which do not require such fine surface or close adherence to gauge thickness.

English steelmakers have, with practical unanimity, adopted the two-high reversing mill; it is superior and much more regular with respect to surface finish; the drafting of the rolls is much simpler and admits of more ready adjustment; the live roller tables are much more reliable in that they are fixed and can be made as heavy and strong as desired.

Another very important advantage possessed by the two-high reversing mill is that, when roughing down slabs, during which the passes are short, the mill can be driven at slow speed, so as to minimize the shock when the slab enters the rolls, while during the long passes the speed can be accelerated to any desired extent compatible with safety. The author has taken notes of the speed at which reversing engines are regularly driven and finds 140 r.p.m. quite common. This is quite twice the speed of the three-high mills, so that the slowing down during the initial passes is amply compensated for before the finish. This method of working is obviously much easier on the mill plant than where the slab enters the rolls at full speed, as in the three-high system causing violent shock and increased liability to breakage.

While for these reasons the practically unanimous choice of English plate makers has been the two-high reversing mill, two new installations of three-high mills have recently been made, one in Scotland and one in England.

The chief part of the paper is devoted to a description of a new form of plate mill, having rolls 30 in. diameter by 6 ft. 6 in. long, designed by the author specially for rolling light plates, but equally suitable for ordinary ship and girder plates. This mill is now successfully at work at the Glasgow Iron & Steel Works, in Warshaw. The principal features of this new rolling mill of Mr. Lamberton are as follows:

Simplification in the Operation of Mill and Reduction in the Amount of Machinery Required.—This is accomplished by arranging the roughing and finishing rolls in tandem, instead of the usual practice of arranging them in the same extended line. The slab is first reduced in the roughing rolls, and finally in the finishing rolls. During the process of roughing down the top finishing roll is held up clear by its hydraulic balances, and the plate under treatment passes freely through the finishing rolls until reduced to the thickness ready for finishing, when the upper roughing roll is raised, and the upper finishing roll lowered and the subsequent finishing of the plate takes place through the finishing rolls.

Reduction in the Work Done by Finishing Rolls and Consequent Reduction in Wear.—In the ordinary type of mill, where the roughed-down slab has to be transferred sideways to the finishing rolls, the practice is to make this transference while the plate is still of considerable thickness that it may not cool too rapidly during the process, so that, generally speaking, as many passes are made in the finishing rolls as in the roughing-down rolls. The author considers this bad practice, inasmuch as it imposes a great deal more work and entails much more wear on the finishing rolls than is necessary. The operation of finishing should be done with the minimum number of passes, so as to reduce the wear on the costly finishing rolls to the lowest possible point and maintain their surfaces perfect as long as possible.

His new form of mill is specially designed to effect this, as the roughing-down process can be carried on during 80 per cent of the whole operations of rolling a plate, owing to the fact that it never requires to leave its direct line of travel, and the finishing process, representing some 20 per cent only of the whole work, is all that need be put on the finishing rolls. It is obvious that a very considerable saving must be effected in the finshing rolls, which have their work so substantially reduced and their surface will be maintained in good condition for a much longer time. Further, the expense in changing and dressing rolls will be greatly reduced, and stoppage of the mill rendered less frequent.

Acceleration in Delivery Speed of Finishing Rolls and Equalization of Power Used in Roughing and Finishing Rolls.—From careful observations and diagrams taken from engines driving two-high plate rolling mills it has been found that the process of roughing-down requires very considerably greater power than that for finally finishing the plate in the hard rolls. This means that the engine, which must be of sufficient power to give out the maximum demand made upon it, is over power when the finishing process is in operation, and the author utilizes this excess power in accelerating the speed of the finishing rolls over that of the roughing. This results in the double advantage of equalizing the load upon the engine during the whole of the operation and consequently increasing its efficiency, and also of providing a most useful increase in speed during the final passes when finishing the plate which, when rolling thin plates, is of very great importance.

Final Delivery of Plates, Straightened and Free from Wave.—In mills driven at high speed there is a tendency for the plate to become waved, particularly if it is of thin gauge, and the higher the speed the more pronounced is this tendency. To correct this, during the final pass in the finishing rolls, the roughing rolls are also put down in light contact with the plate.

and the mill then practically forms a four-roller mangle which very effectually flattens out the plate before going to the shears.

Further advantages are a *reduction in space* occupied by the whole plant (the saving in space amounting to about 40 per cent) and *a large output capacity*. The latter is obtained (1) by the simplification of the operation of the mill, in which the transference of the plate from roughing to finishing mill is abolished and the time taken for this operation saved; and (2) by the acceleration of the speed of the finishing rolls, which are driven 15 per cent faster than the speed of the engine. The result is that a plate of, for example, 5 ft. x 30 ft. x 5/8 in., can be rolled in two minutes, and if this rate of feed could be kept up the output of such plates would be 400 tons per day of 10 hours. In rolling to thin gauge the slab is thinner and the time taken for a plate of, for example, 5 ft. x 30 ft. x 3/16 in., is two and a half minutes, or at the rate of 130 tons per day of 10 hours.

Special attention has also been paid to *steam consumption*. The engine driving the mill described is of the vertical and horizontal type, compound condensing, and has a high-pressure cylinder 42 in. diameter and a low-pressure cylinder 67 in. diameter by 4-ft. stroke. The steam pressure is 160 lb. per square inch; the exhaust is connected to a central condensing plant giving a vacuum of about 24 in., and the engine under these conditions develops the exact amount of power required.

To ensure quick reversing the handling valves of both high-pressure and low-pressure cylinders are connected and worked in unison from the same starting handle as is now usual in modern compound engines. The closing of both these valves simultaneously acts as a most efficient brake, stopping the engine quickly and preventing racing at the finish of the passes. The resulting increase in pressure in the receiver is then available for accelerating the speed of starting for the return pass, and so the efficiency of the whole operation is substantially improved.

Finally the author refers to the question whether the rolls should be worked wet or dry. The finishing rolls are generally worked wet, but this is not so with the roughing rolls. It seems only reasonable to believe that, if all rolls could be worked wet, it would greatly extend their life and would prevent necks overheating and cutting into their bushes. "The solution is to be found in the increased speed of driving which enables plates to be rolled with such rapidity that the cooling effect produced by working the rolls wet is discounted by the heat generated by the work expended on the plate in reduced time. From careful experiments made on a large number of plates rolled from the same slabs it has been ascertained that the surface quality of plates rolled when both roughing and finishing rolls are worked wet is very distinctly superior to those produced when only the finishing rolls are worked wet. This clearly points to the advisability of all plate rolls being worked wet."

The discussion of Mr. Andrew Lamberton's paper was then opened by Mr. James Riley, who said it was a real pleasure to him to have read and listened to this paper. Thirty years ago the mill at Hallside works turned out 80 tons per week on one shift and the workmen said the rolls could not do more without getting hot—"they would burst;" but the modern output was 2000 tons. The first three-high mill in this country he put down 15 years ago. It turned out three times the weight of plates that the old mill did; but the roll gave trouble, particularly the tables. He agreed almost entirely with the author's conclusions except, perhaps, that the complications in the motor required consideration.

Mr. Harrison quite agreed with the majority of Mr. Lamberton's proposals, but doubted whether the "mangling" action resulting from the top roughing roll being lightly let down at the finish would be quite satisfactory, because if let down too lightly there would be practically no effect, and if too hard the plate would be stretched too much. Did the author want to heat plates by the work done on them in the mill? If so, it was an expensive way of heating.

Mr. Gledhill said that if he reconstructed his armor plate mill he should follow the author's excellent arrangement. But with regard to rapidity in rolling plates exceeding a certain thickness, when the surface is worked out at a higher rate than the interior, the centers become unsound and the ends of the plate are distinctly concave. Immunity from breakdown was very important. In the structure of his armor plate mill castings were not accepted; the rolls, 4 ft. in diameter, were forged from ingots of nickel steel of 80 tons each, and the housings and light engine cylinders were also made from forged steel ingots. There had been no breakdown in seven years' continuous working.

Mr. Cunningham felt quite sure tandem rolling would come to the front. The best distance between the rolls would be determined by experience. He estimated that at present 63 per cent of the work was done in the soft rolls and 37 per cent in the hard rolls. Experiments on wet rolling with plates 5/16 in. thick and less showed a saving of 1.5 per cent in pickling solution for wet-rolled plates, owing to a lower proportion of surface oxide.

Mr. Crowe thought that two sets of three-high rolls driven by independent engines would give a larger output than a mill on the author's plan; but that entailed increased expense. Mr. Lamberton's mill would probably give the greatest output to be obtained with one engine. Against the saving in time effected by the abolition of skidding, the time occupied in screwing down should be considered. Then, too, the condition in which the plates were received from the cogging mills counted considerably. He considered that the housings of the two mills might be advantageously placed farther apart. He congratulated the author on the production of a reversing engine of the type described, and thought these rolls especially adapted for electric motive power. No doubt the slight stretching consequent on the the soft rolls running somewhat more slowly than the hard rolls during the "mangling" action would effectively straighten the plates.

Mr. Duff said the output of Mr. Riley's three-high mill in 1890 was often more than 400 tons per week. He quite agreed that fast, wet running produced superior surface finish. The great defect of the three-high mill was the weakness of its live-roller tables, and if this had been remedied he had no doubt that the output and general results would have at least equalled those obtained by the author's mill.

Mr. Lamberton replied that Mr. Riley need have no fear of complications arising from the engine. It had all the advantages of double-compound engines with less complication. The high- and low-pressure valves were connected by rods to a single lever, and when shut down they closed together, and formed a most efficient brake, which quickly brought the engine to rest. Mr. Riley's estimate that the mill could roll plates 80 ft. long might be exceeded; he hoped to produce plates 100 ft. long. Putting the rough holls lightly down at the finish straightened the plates not so much by stretching as by preventing wobbling. Mr. Harrison had enquired as to the plate being heated in working. He did not undertake to heat plates by putting work into them at high speeds, but what he said was that the rapidity of rolling diminished the loss of heat by cooling in the mill. Mr. Gledhill's remarks referred mainly to armor plates, the conditions appertaining to which were quite different from those of rolling thin plates. He did not claim priority in the use of a reversing-compound engine, but only for the two-cylinder engine as distinguished from the four-cylinder engine. Mr. Crowe's proposed combination of two three-high mills would obviously increase the outlay with the production, and he saw no advantage in increasing the distance between the housings, which would complicate the transmission gearing. Electric driving was simply a question of cost, and meant two 3000-hp motors instead of one engine. He perfectly remembered the three-high mill mentioned by Mr. Duff,

but not favorably. It was a somewhat shaky structure, frequently stopped by breaking down, and it was difficult to reconcile Mr. Duff's statement of its performance with the fact that it was not now in existence. In conclusion, he claimed that the correct method of rolling plates was to equalize power between the soft and hard rolls.

The president moved a vote of thanks to Mr. Lamberton, and congratulated him on his valuable work. Those who had taken part in the discussion were also to be commended for their observance of the time limit and their close adherence to the subject-matter of the paper.

A New Fatigue Test for Iron and Steel.

A paper by Dr. T. E. Stanton, of the National Physical Laboratory (London), describes a new fatigue test for iron and steel based on observations of Kirkaldy, who traced the failure of steel rails to the development of cracks in the upper worn surface, brought about by repeated bending. Dr. Stanton, therefore, devised a laboratory test combining rolling abrasion and alternate bending. The principle is shown in Fig. 1.

R is a hollow ring of rectangular section cut from the steel rail to be tested, and placed between three hardened steel rollers symmetrically placed as shown. If the upper roller is loaded with a weight W, the ring will be in eqiuibrium under three equal forces W at the lines of contact and by rotating the upper roller motion will be communicated to the lower one by the rolling friction of the ring. In this way the outer surface of the ring will be subject to rolling abrasion, and every radial section of the ring will be subject to alternate bending stresses which will go through a complete cycle three times in one revolution, and the magnitude of which can be calculated from the dimensions and the load.

FIG. 1. — PRINCIPLE OF TESTING MACHINE.

A machine based on this principle works satisfactorily with the exception that the load on the upper roller could not be made considerable, owing to the resistance of the bearings of the lower roller which soon became greater than the frictional resistance at the line of contact with the specimen. The result was that when this limiting load was reached, the specimen ceased to rotate and a flat was at once worn on its surface by the upper roller, rendering it useless for further testing.

A new machine was therefore designed and constructed, and is shown in Fig. 2. In this the axles of the lower rollers are supported on the rims of friction wheels, an arrangement which proved quite satisfactory, the specimen rotating uniformly up to the highest loads used until fracture occurred.

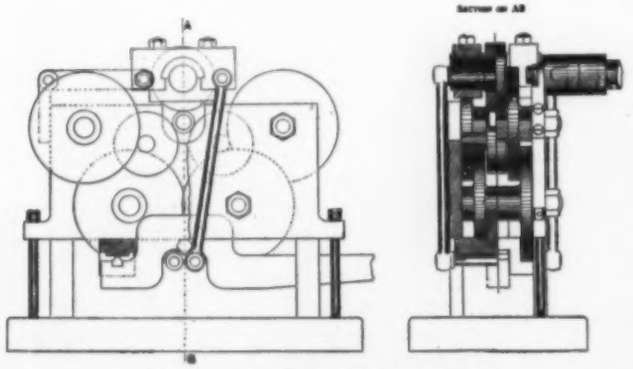


FIG. 2.—FATIGUE-TESTING MACHINE.

The rollers and their axles are made of tool steel hardened and ground to the same diameter. The upper roller revolves in a double brass bearing, which is hinged to the side plates of the machine, and motion is communicated to it from a shaft parallel to its axis through an Oldham coupling, which allows the roller to sink without constraint as the specimen wears away. The load is applied by a weighted lever whose knife-edge rests on a saddle supported from the bearings of the upper roller by the side rods shown in Fig. 2.

The behavior of a specimen under test consists of a wearing down and spreading over the edges of the outer surface to an extent depending upon the hardness of the material. After some thousands of rotations the surface begins to slightly disintegrate and falls off in thin flakes. As the test proceeds, after a time, depending, of course, upon the load, small cracks running parallel to the axis begin to appear on the inside or outside surfaces, or both. These develop until the specimen is no longer able to sustain the load and fracture occurs. On examining the surface of a specimen after fracture it will be generally found that there are innumerable small cracks running across the surface parallel to the axis which are only visible in the microscope.

The author illustrates the application of this method by giving the results of a number of tests made on specimens cut from sample rails of an English railway company. The results indicate clearly the marked superiority of nickel-steel rails, both in regular resistance to rolling abrasion and resistance to alternating bending. The number of reversals of stress up to fracture is very materially greater with nickel-steel than with other steels.

The calculated ranges of stress from tension to compression at the outer radius of the test ring were from 35 to 40 tons per square inch. The calculated stresses at the inner radius were about 15 per cent greater, but it is noteworthy that the cracks which ultimately caused the failure of the ring appeared to originate on the outer surface of the ring in the case of the hard steels and on the inner surface in the case of the softer steels. This is probably due to the greater spreading of the material sideways in the softer rings, due to the rolling abrasion.

Another interesting result is that although, broadly, a high value of the hardness number corresponds to long endurance to alternating stresses and abrasion, yet in several cases an increase in the hardness number is accompanied by a diminution of endurance. Another feature of the tests is the greater endurance of the two samples of least tensile resistance and greatest ductility. This is probably also due to the spreading and hardening of the material at the outer surface of the soft steels. A similar effect to this in practice has been observed in which it was found that the loss of weight for the first 30,000 trains was 28 per cent greater for the soft than for the hard rails, but that the wear due to the next 65,000 trains was 9 per cent greater for the hard than for the soft rails.

Dr. T. E. Stanton having read his paper on "A New Fatigue Test for Iron and Steel," Mr. Gledhill led the discussion. The paper was decidedly instructive and appealed to him particularly because it demonstrated the superiority of nickel steel. But the test rings were so cut that the strains were in a longitudinal direction, and it would be more useful to take the sample rings transversely. The apparatus was ingenious and practical.

Mr. Hadfield thought the method of test was original and congratulated the author. Low-carbon nickel steel would not wear well, and he enquired if Dr. Stanton had records of nickel steel rails in service. He considered this a most important matter.

Mr. A. Windsor Richards did not think the test comparable with service conditions, nor were the results comparable in themselves, for the hard rings gave way exteriorly and the softer samples interiorly. One rail which had stood 35 years' wear had given bad results in this test, and would probably have been rejected if it had been made to-day. Then, too, rails with high phosphorus and sulphur showing but slight wear after 25 or 30 years broke down under the reversal test. The selection of the portion for test was unfortunate; it was the weakest

part; a thin layer should be taken just under the running surface.

Mr. E. H. Saniter pointed out that the ring as selected would have two different directions of fiber. Fracture did not occur in these tests in the same direction as under service conditions; he considered the test unsuitable and that results given on p. 10 of the paper indicated that the test was not reliable.

Mr. W. Webster hoped the experiments would be extended, but test pieces should be taken with their axes parallel to the length of the rail. Certain thin sections from the head of a rail would bend longitudinally into a semicircle of 1½ in. radius, but with transverse bending they broke at 20 deg.

Dr. Stanton, in reply, said he only wished to illustrate the method of testing and not any particular results. He was glad attention had been called to the selection of specimens for test. He had adopted the plan described as that by which the action of wheels on the rails would be simulated as nearly as possible.

Mechanical Treatment of Steel.

A paper by Mr. JAMES E. YORK (New York) discusses the physical qualities of steel in relation to its mechanical treatment and emphasizes that, especially for rail making, the mechanical treatment of the steel is comparatively of much greater importance than its chemical composition, the latter being now well under control.

The chemical composition of steel ingots may be all that can be desired, but if they are not properly heated the quality of the steel is seriously affected. It seems rational at first sight to consider as the most successful heater a man who can guess the hottest temperature, at which the steel will roll without cracking, as naturally the hotter the metal the softer it is, and hence the reduction is easier and more rapid. However, this method has two serious defects; first, that overheating destroys the best structure of the steel, and, in addition, the finishing temperature is so high that no proper fining of the grain is possible.

Mr. York strongly urges to stick to these two principles: 1. That the finishing temperature should be as low as is possible to get best results, and that the initial must not be above another limit, about 950° C. 2. That if under these conditions the ingot cannot be rolled to 4-rail lengths in one operation, the initial size should be reduced.

Mr. York discusses the lack of penetrative action in rolling and, as a consequence, the impossibility of closing a pipe in the rolling mill, the pipe being merely stretched proportionally with the billet. Therefore, it is absolutely essential that the ingot should be comparatively free from pipes and blowholes before the operation of rolling commences in the blooming-mill, otherwise there cannot be produced a billet of proper structure from the top of the ingot, and consequently the rail with the necessary physical qualities cannot be produced unless the ingot is solidified before it is bloomed, or the necessary top portion sheared off after.

The necessity for some cheap, quick and efficient method for solidifying ingots has induced Mr. York to apply his method of transverse rolling to this problem. Fig. 3 shows an end elevation of the mill with six ingots in place for treatment.

The ingots are arranged alternately reversed so as to save room, and the number of ingots may be increased or diminished as is found desirable or the dimensions of the mill allow. The ingots lie on a comparatively level horizontal table, and are first operated on by the plain roll No. 2, which closes any surface blowholes.

The ribbed roll No. 1 is so constructed that the distance between the ribs corresponds to the distance between the centers of ingots and the corresponding rib on the base; the ribs are preferably made removable so that they can be provided of the right length and contour to suit any particular series of ingots, but in all cases the rib must be longer than the pipe to be eliminated. The operation of rolling involves the use of comparatively little power, since the metal is merely shifted inwards along the line of the pipe.

It will usually be sufficient, owing to the taper of the ingot, to have ribs of the same depth throughout, and in consequence the rib will make contact first at the bottom of the pipe, and will gradually squeeze out any segregated material. However, if desired, the ridge may be tapered, or the plain roll may have a collar at any particular point for the purpose.

With this method the ingot will be left with two grooves of semi-circular section which, however, will not interfere with the subsequent rolling. To avoid this, if desired, the ingot may be cast with ridges, which when forced in will leave the surface comparatively plain.

In then discussing the rail-finishing mill, the author points out that the work done by the rolls working with their faces parallel in the manufacture of blooms, plates and flats is satisfactory. It is only when rails and other flange sections have to be produced that the more elaborate rolls required do not give the same satisfactory results.

It is clear that the metal in the web and head is the only part of the billet which receives any material reduction, and as the

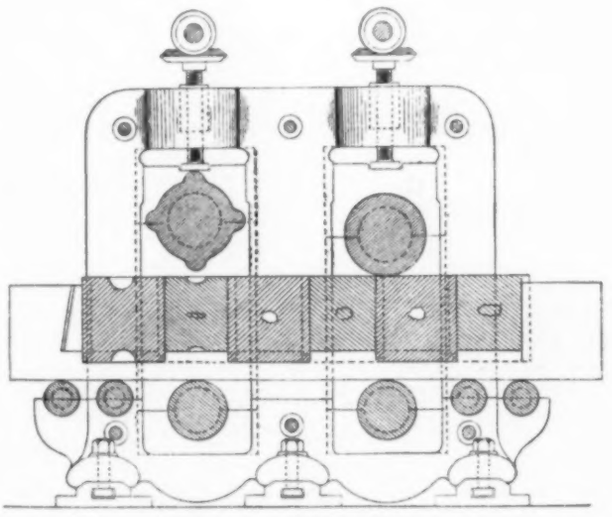


FIG. 3.—ROLLING MILL.

flanges and head are gradually formed, less and less true rolling action is performed upon them. The action which can take place in these parts, where the roll surface is at right angles to the rail, can only be largely of the nature of wedging or drawing. The result of this must be a condition of unequal stress in the flanges.

Another serious defect in the use of these rolls for flange sections is the great difference of surface speed at different parts of the section, the diameter of the roll forming the wedge being frequently 5 inches larger than a portion in contact with the extremity of the flange, and sometimes more. As a consequence the web is delivered from the roll much faster than the flange, where the metal must either slip or stretch to compensate for this. This is the principal reason why, when the flange breaks, the fracture is almost always crescent-shaped.

By a method which he describes, Mr. York has established the fact that the remarkably good quality exhibited in certain rails made forty years ago was obtained by rolling at a low initial temperature. Taking a 14-inch ingot he found that it required thirty-two passes to obtain a 65-lb. rail. "It is not to be supposed for a moment that the most skilful steel manufacturers in the world at that time were working these at a lower capacity for amusement, and if similar good qualities are required to-day it is necessary to work under relative heating conditions."

At the present time a 22-inch square ingot weighing 2 tons can be rolled into four-rail lengths in fifteen to twenty passes, and it is clear that a considerably higher initial temperature must be employed, with the result that there is less effective

work on the material, and that the resulting quality is inferior.

Steel rolling, with the conditions of greater hardness and lower temperature, requires a harder and stronger roll than was the case with iron. However, the only class of roll which keeps its shape under the condition of work now required is the hard chilled roll, which cannot be adapted for deeply-grooved rolls, as now used in rolling rails at the finishing passes.

Mr. York finally refers to his universal mill, which can give the finishing passes at the lowest possible temperature and with the hardest surface to the rolls. Owing to the special construction of this mill, beams of small depth with a 12-inch flange can be delivered perfectly straight from the roll. Also, owing to the presence of the side roll, rails can be produced without the internal strains mentioned above, and, in consequence of the possibility of doing more work there with a better wearing quality metal in the head.

The high speed given to rolls in modern rail-mills has often been considered to be one of the chief causes of inferior rails. This is in a large degree a mistaken idea. If the metal being rolled is comparatively solid and has not been overheated and the rolling action is on proper lines, there will be no damage to quality other than incidental to the shape of pass; the speed of delivery of a modern rail-mill is about 650 feet per minute.

The York universal mill is now rolling beams at a speed of about 1600 feet per minute without deteriorating the physical qualities of the finished product. This is made possible by side-rolling action, which dispenses with the different speed delivery referred to in the ordinary mill, also the wedging and drawing action now inherent to the ordinary process when rolling rails and other flange sections.

A New Electric Steel Furnace

A paper by Prof. B. Igewski (Kieff, Russia) describes "a new type of electric furnace for the smelting of iron" (already briefly described in our Vol. V, p. 141). The chief advantages are stated to be the use of high voltage, absence of carbon electrodes, a high temperature of the slag, and a "minimum amount of surface contact with air or with the walls of the furnace."

The furnace is of the resistance type and the special feature is that the resistor is a conductor of the "second class" (electrolytic conductor), like magnesia, lime, silicates or their colloides, such as Al_2O_3, 2 SiO_2, which, on being greatly heated, become conductors.

Fig. 4 is a cross-section of the furnace; *a a* are fire bricks, the inner surfaces of which form the resistor proper; *b b* are thin iron-sheets inserted between the bricks and leading the three-phase currents from the collector brushes *e* outside to the inside of the furnace. These brushes *e* are stationary, while the furnace rotates in the direction of the arrow, at a speed of about 20 revolutions per minute; *c* is the molten charge.

The author states that he has had several years' experience with this furnace, but only in the laboratory. The author prefers the use of three-phase currents, but usually employs a continuous current of 250 volts and 50 to 60 amperes, i. e., 12-15 kilowatts. When cold the furnace is a non-conductor.

The process of smelting is conducted in the following sequence of operations: The flame of a gas or Bunsen burner is made to impinge through the working opening, and when the furnace has been slightly warmed a little damp potassium hydrate is charged and the furnace is rotated. It will now be found that the furnace acts as a conductor, and the electric current begins to warm it. After a short time sodium hydrate is added, and when the interior of the furnace is red hot, sodium carbonate is charged. The corrosive alkalies which evaporate within the furnace do not cause as much harm as might be expected. Rapid heating is, however, a danger to the bricks, which begin to crack.

The best plan is to warm the furnace with gas during the night preceding the experiment. When the temperature of the furnace reaches a light red heat cast iron may be put in, and then scrap, or the order can be reversed. In the first case the author is in the habit of adding the new material gradually as the charge melts. In the latter case, when the iron becomes sufficiently hot, the smelting takes place at once on the addition of cast iron.

If a quantity of cold metal be suddenly introduced at one time, it is easy to reduce the temperature to such an extent that short circuiting occurs. The same thing occurs if the furnace becomes cool with the metal inside; small furnaces cool down in an exceedingly short time. In a large furnace where there is a considerable margin of heat, such an accident is hardly likely to occur. Indeed, in order to bring them into working condition, it would suffice to charge some hot slag from some other furnace and to avoid having recourse to soda, which could not be other than injurious to the bricks.

"The outer bricks of the author's furnace are of fireclay, and the inner of fireclay or dinas. The fireclay bricks are fairly good conductors, but the dinas bricks are exceedingly poor conductors. The author has, however, used both for years with successful results. With fireclay bricks care should be taken that less slag should be used. With dinas bricks it is his custom purposely to add fluorspar, cryolite, magnesia and similar substances in order to increase conductivity.

"Magnesite bricks appear to be ill-adapted to the purpose, because they conduct too easily, while the current of 250 volts

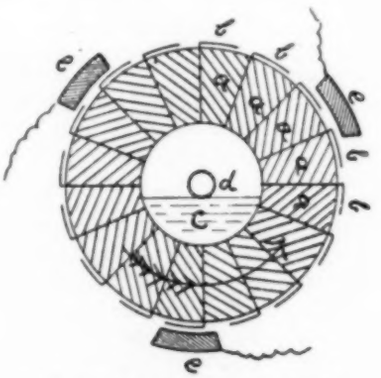


FIG. 4.—ELECTRIC STEEL FURNACE.

would, with the existing dimensions of the furnace, be too great for these bricks. Experiments with dolomite and other bricks have not yet been carried out by the author."

As a rule the author smelts a small quantity of cast iron and afterwards adds scrap. "The softest steel produced possesses an ultimate strength of 56.8 kilograms per square millimeter, with an elongation of 20 per cent."

On smelting iron turnings with charcoal (1 per cent), steel was produced with an ultimate strength of 85.6 kilograms per square millimeter, and an elongation of 3 per cent. Experiments for the production of steel from cast iron by the ore process were also successful, and the fireclay bricks suffered less than might have been anticipated.

Color Photography in Metallography.

A paper by Mr. E. F. Law (London) deals with the "application of color photography to metallography." In the examination of alloys under the microscope a difficulty is frequently met with in selecting an etching agent capable of distinguishing the different constituents, and this is especially the case when it is required to show the constituents in a photograph.

In order to overcome the difficulty, and increase the actinic contrast between the constituents of an alloy, Professor Martens suggested heating the polished specimen until a film of oxide formed on the surface. Owing to the different rates at which the constituents oxidize, they assume different colors, and can be readily distinguished and photographed.

The same results, but sometimes showing more brilliant colors, may be obtained by simply allowing the polished surface

to tarnish by exposure to the atmosphere, and modifications of the process consist in heating the specimen in air containing iodine, bromine or sulphuretted hydrogen.

In such cases the present author has found the Lumière autochrome plates to be very useful for producing colored microphotographs. The disadvantage of the process (but probably only a temporary one) lies in the difficulty of obtaining prints on paper. On the other hand, the time spent in the dark-room is about three minutes, most of the operations being carried out in full daylight, and a photograph can be taken, developed, dried and bound as a lantern slide in less than one hour.

(To be concluded.)

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Faraday Society Meetings.

At the meeting of the Faraday Society, held on February 25, a paper by Dr. Veley on hydrolysis and a paper by Dr. Knox on a study of the sulphur anion and of complex sulphur anions were presented which were chiefly of theoretical interest, but elicited a very extended discussion.

At the meeting on April 28, papers were read by Professor A. K. HUNTINGTON and Dr. C. H. DESCH on "The Planimetric Analysis of Alloys and the Structure of Phosphor-Copper," and by F. E. WESTERN and H. R. ELLIS on the "Interaction of Aluminium Powder and Carbon." (See page 256 of our June issue.)

In the discussion on the first of these Professor W. W. Haldane Gee communicated a suggestion that the method might be used to compare the relative losses of the constituents of an alloy after prolonged etching with different reagents, and so help to throw light on the method of corrosion. It would be of especial interest to apply planimetric analysis to alloys which had been electrolytically corroded as anodes in various saline solutions.

Replying to a question, Dr. C. H. Desch said that general applicability was not claimed for the method, for where the alloy was homogeneous—as in many low percentage bronzes—it was useless. Also a state of physical equilibrium was essential; and slow solid diffusion often took place even after careful annealing. The chief point that he wished to accentuate was the effect of segregation, for this had not been previously pointed out; and he believed it occurred more generally in alloys than was usually supposed.

Professor A. K. Huntington remarked that when proper curves were obtained the method would probably be satisfactorily extended to the examination of phosphor-tin alloys. The subject would well repay study, as by its means insight was gained into the constitution of alloys which can never be supplied by chemical analysis.

Discussing Messrs. Western & Ellis's paper, Dr. F. Mollwo Perkin said he did not altogether acquiesce in the view that the reaction was due to reduction of CO and CO_2 subsequently to the oxidation of the carbon. He had no evidence that CO could be reduced at 1100° C. Possibly the heat evolved by the action of the nitrogen on the aluminium might contribute. It would be of interest to heat aluminium powder in streams of CO and CO_2 and observe the temperature at which reduction occurred. The initial reaction was more likely to proceed from the superficial oxidation of the aluminium.

Mr. Charles Weiss mentioned that carbides were sometimes found in the complex matter at the bottom of the aluminium furnaces; and generally these carbides were entirely enclosed in an envelope of aluminium oxide.

Mr. H. R. Ellis gave further particulars concerning the production of nitride, and stated that he considered that the formation of nitride was more probably due to the action of nitrogen on the carbide at a high temperature than to the nitrogen combining directly with the metal, for it has been abundantly demonstrated that the carbide is readily attacked by nitrogen at high temperatures. Crude carbide strongly heated in a stream of nitrogen readily absorbs this gas, which is evolved as ammonia on treatment with water; but for the successful absorption certain impurities are necessary. The crude carbide can be prepared from clay and carbon in an electric furnace, and might possibly be used to absorb atmospheric nitrogen as successfully as calcium carbide is used in the cyanide process.

Professor A. K. Huntington was disposed to agree with Dr. Perkin as to the cause of the reaction, but possibly the reaction was of a triple nature and was brought about by the presence of CO or of CO_2 between the two solids which would not interact alone. Reactions between solids were often induced with difficulty, and in this case the gas, unlike the solid carbon, might permeate the film of oxide enveloping the aluminium, thus reaching the actual metal and starting the reaction. He greatly appreciated the care with which the experiments had been conducted by the authors, and the consequent value of their work.

Dr. Richard Seligman communicated his concurrence with the conclusion that the carbon and aluminium unite directly, and that the intermediate formation of carbon monoxide is not necessary. He had often found the carbide in parts of the furnaces to which air could scarcely find access.

Mr. F. E. Western, in reply, said that he felt certain that the initial action was the oxidation of the carbon. This was evident from the appearance of the reaction, which began at a dull red heat beneath the surface, and bright incandescence at the actual surface followed—but not immediately. Unquestionably CO was produced, because its blue flame was apparent in cases in which the crucible had cracked.

MAY MEETING.

At the ordinary meeting on May 12 three papers were read. The first was by L. O'DOWD and F. MOLLWO PERKIN on "The Determination of Boiling Points of Very Small Quantities of Liquids."

In the discussion Dr. Senter asked if it were quite certain that the liquid in the inner tube has the same temperature as the surrounding liquid. The liquid in the inner tube was not stirred, and its temperature might not be quite uniform; moreover, this would be affected by the velocity of cooling through the walls of the thin tube.

Dr. Perkin replied that the test tube was of very thin glass. He estimated that the difference from the true value would not be greater than one-tenth of 1° C. Stirring as described effected equalization of temperature.

Dr. Perkin then read his paper on "The Industrial Uses of Ozone," particularly for the purification of water.

The chairman, M. Leon Gaster, opened the discussion. He said that the subject was one of great interest, and described a large ozonizing plant at Philadelphia which was very satisfactorily used to purify the Schuylkill river water, reducing the number of bacteria from two-and-a-half millions to only twenty-five per cubic centimeter. Boiling was not so effective as was commonly supposed; water required to be boiled three times to remove bacteria with any approach to completeness. Filters were dangerous, because proper cleansing was not always attended to if it were practicable. But ozone destroys bacteria altogether. He wished to ask the author how the apparatus was regulated for production of ozone without oxides of nitrogen. It was a great triumph for the electrochemist to have produced such an apparatus—especially the portable form.

Dr. Veley remarked that some years ago when working on pure nitric acid he found that the best method of removing traces of nitrous acid was to let the nitric acid trickle through an atmosphere containing ozone. As to the residual bacteria, it was fortunate that pathogenic organisms were easily destroyed. Some bacteria would stand anything, even rum of 80 per cent, and as a rule such were not harmful. A reliable account of sterilization by ozone was most useful, because some forms of apparatus merely passed current through the water,

and the public was led to think that this effected ozone sterilization.

Dr. Lowry was more impressed with the portable form than with the larger plants. For town supplies he advocated the lime softening process, in which the precipitated calcium carbonate removed bacteria.

Dr. H. Borns considered that the self-purification of river water by oxidation, when the flow was rapid, rendered but little purification necessary. Siemens and Halske's bacterial figures had been assailed, but the results were certainly favorable.

Dr. G. Senter asked if there were difficulty in removing the last traces of ozone from the water. With regard to the proportion of ozone obtainable, Fischer had got 30 per cent.

Dr. Perkin then replied that in the Siemens' apparatus oxides of nitrogen were not produced. The quantity of ozone remaining in the water after treatment was very small, and was entirely removed by subsequent oxidation.

At the conclusion of the meeting Dr. Perkin exhibited a form of the apparatus at work.

Dr. V. H. Veley's paper on "An Apparatus for the Determination of the Dielectric Constants of Non-conducting Liquids" was not discussed.

LORD KELVIN.

Sir Joseph Swan occupied the chair at the meeting on May 26, when Sir Oliver Lodge delivered his presidential address, his subject being "Some Aspects of the Work of Lord Kelvin."

Sir Oliver said that when a man of the first magnitude worked from less than twenty to over eighty years of age the output was so great that no criticism could render complete justice. He would review only the chemico-physical part of Lord Kelvin's thoughts to the kinetic theory of solidity—that matter in its ultimate state might be the product of ether in motion. Some years before his death he seemed to be abandoning his position; and when, at a meeting of the British Association, Sir Oliver challenged him as to the constitution of the atom, he fully justified his views though not proving their correctness. It may seem that he was satisfied with the postulate of action at a distance across empty space instead of through a connecting medium, but that may have been but a stepping stone to a still greater theory.

What great generalization will be associated with Lord Kelvin's name? It is not easy to answer; but what emanated from him in 1851, when immersed in the doctrine of the conservation of energy, would perhaps constitute his greatest memoirs. His keenness and perception then were astounding. Grasping all the known theories, he seized on facts emanating from Carnot and Joule, and elicited therefrom a series of striking and beautiful discoveries. The answer of posterity will probably be the development of the doctrine of conservation of energy and its application to thermodynamics.

Joule's work might have been altogether rejected but for Lord Kelvin's recognition of it. Heat can be converted into work, and is not like water in this respect, nor like electricity. Carnot, with others, thought differently; but Joule proved it.

Of all the memoirs dealing with electricity, "Transient Current," published in 1853, is perhaps the most striking, giving the whole theory of electric oscillations. The fundamental equation was an inspiration in 1853, although it is written glibly enough now. The idea of kinetic energy in a current—the starting point of self-induction—really dates from 1848. It seemed to Sir Oliver an amazing kind of insight which led Lord Kelvin at that period to attribute something akin to specific heat to electricity. In his investigations of thermo-electricity he met with the good fortune that often attends those who do not hesitate to incur risk. There was a possibility that his discoveries might not have turned out to be true; but they have proved so.

In connection with Lord Kelvin's work on absolute measurement, Sir Oliver remarked that the invention of suitable units for electrical and mechanical measurements was not a simple matter. Absolute measurements had nothing to do with the C.G.S. system, but might be based on wave-length or atomic mass. The establishment of the absolute zero of temperature was one of Lord Kelvin's achievements. It might be defined as the temperature at which a working substance had exhausted all its heat in doing work, and it was remarkable how various formulæ dealing with great or small expressions of quantities gave the same result.

On the electrical theory of matter Lord Kelvin's mind was somewhat conservative, but we owe to him some pioneer work, instanced by a remarkable paper in the *Philosophical Magazine*, 1891, "Epinus atomized."

Referring to Lord Kelvin's researches in celestial dynamics, Sir Oliver said the density of the whole visible cosmos was that of a vacuum as much rarer than our best obtainable vacuum as that is rarer than lead. If the whole of the matter therein were reduced to globules 2 cm in diameter uniformly diffused, light would be but slightly interrupted by it.

Atoms coalescing would take 17 millions of years to reach the density of water, and only *two hours* longer to attain infinite density at the universal gravitic center.

Sir Oliver did not see any reason to suppose either a beginning or an ending of matter or of space. Lord Kelvin appeared to think differently.

The chairman, in moving a vote of thanks, which was accorded by acclamation, congratulated the Faraday Society on its choice of a president.

Market Prices.

The run of market prices in May was as follows:

Tin:—During May tin has shown a constant downward tendency, varied only by a rise from 132-10 to 137 from the 13th to the 19th. The total drop during the month is from £142 5 0 to £130 17 0.

Copper has been flattish, with a rise to £59 on the 19th. Present prices of electros, £59 10 0 to £60 0 0. Total variation on standard for 1st to 26th nil.

English lead has declined steadily, with slight revival on 19th. Total variation within a pound. Present price, £12 17 6.

Hematite experienced a sharp drop on the 19th, but had total variations within a shilling. Present price, £3 0 6.

Cleveland warrants varied rather suddenly, starting at 51s 6d they rose steadily till the 8th, when the rise became rapid, culminating in 55s 6d on the 14th. After this came a sharp fall to 50s. Present price, £2 9 7½.

Scotch pig has fallen off slightly. Present quotations range from 63s Langloan to 56s 6d Eglington.

Chemicals.

	£	s	d
Ammonia sulphate, f.o.b. Liverpool, per ton	12	5	0
Copper sulphate, per ton	21	15	0
Caustic soda, 77 per cent, per ton	11	2	6
Bleaching powder, 55 per cent, per ton	4	5	0
Antimony, Star Regulus, per ton	£35 to 36	0	0
Shellac, standard T. N., orange spots, per cwt.	5	8	0
Carbolic acid, liquid, 97/99 per cent, per gal.		1	0
Creosote, ordinary good liquid, per gal.			2
Naphtha solvent, per gal.		2	6
Rubber, Para fine, per lb.		3	9
Gutta percha, fine, per lb.	5s 6d to	6	6

American Chemical Society.—As announced before, the thirty-eighth general meeting of the Society will be held in New Haven, Conn., June 30, July 1 and 2. The Society will, as usual, meet in sections on account of the large number of papers to be presented. The sessions will be held in the Sheffield Scientific School of Yale University. Papers must be sent to the chairman of the section or to Dr. Charles L. Parsons, Secretary, New Hampshire College, Durham, N. H. A division of the Industrial Chemists and Chemical Engineers will be organized at this meeting, and a large attendance is expected.

SYNOPSIS OF PERIODICAL LITERATURE.

Industrial Electrochemistry.

Bleach Liquor for Paper Mills.—An article by A. Ahlin in the *Papier Zeitung*, Vol. 33, page 834, and abstracted in Lond. *Elec. Eng'ing* of May 7, deals with European practice of making bleach liquor for paper mills. As a rule, rock salt is employed to prepare the liquors which upon electrolysis produce the bleaching solution. But as the sodium chloride contains considerable impurities, the results obtained with different samples of rock salt differ often greatly. The secondary reactions may cause oxidation, that is, chlorate formation, or, on the other hand, reduction of the hypochlorite to chloride. The author has thoroughly studied the reactions in Schuckert's apparatus. Reduction is caused by reconversion of the hypochlorite into chloride, and takes place when the previously produced hydrochlorite comes into contact with the hydrogen at the cathode, which at the moment of losing its electrical charge is in a very active condition. One method of preventing the reduction is the addition to the electrolyte of salts which, when their cations are yielded up at the cathode, form insoluble hydroxides, which act as protective diaphragms. As a matter of fact, it is not always necessary to add these salts, as they frequently occur as impurities in the salt employed to make up the electrolyte. The author recommends that the efficiency of each electrolyzer should be checked by drawing a curve with chlorine strengths plotted as ordinates and times of electrolysis as abscissæ. By means of such curves it can be shown when any of the electrolyzers are not giving normal results. It is also important to give constant attention to the temperature and the alkalinity of the liquor. It is necessary to keep the temperature low, and the alkalinity should also be very slight, such that 1 litre of the solution when colored with phenolphthalein shall have its color discharged when two drops of normal acid are added. In any case, before employing the liquors for bleaching, the alkalinity should be neutralized. Some authorities prefer to have magnesium chloride present, but the author considers its presence objectionable, as it produces heavy deposits upon the cathode, which set up a resistance and impede circulation of the solution. He considers that the anodes, at any rate, should be of platinum, which if the metal is polished, is very little acted upon even when employed for a long time.

Copper Refining.—In an article by J. B. C. Kershaw in the Lond. *Electrician*, June 5, reference is made to a process of H. G. Dolphin for improving the circulation and aeration of the electrolyte in the copper depositing vats, which is stated to have recently been installed in several British refineries. "Siemens & Halske use compressed air for agitating and aerating the electrolyte, while Dolphin makes use of the force of gravity and causes the electrolyte as it enters the vat to draw in with it the requisite amount of air. The advantages of this method of feeding the vats are stated to be as follows: The electrolyte is always of one density throughout the vat, and an absolutely steady motion is given to the liquor entering the vat from the feed tube. The silver slimes are not disturbed, and the cathodes do not contain more than ½ oz. of silver per ton of copper. The iron in solution is oxidized and is precipitated with the other impurities on the floor of the vat. The cathodes are practically free from nodules, owing to the air bubbles which form on their surface being constantly removed by the friction of the electrolyte. The possibilities of short-circuits are minimized."

Iron and Steel.

Boiler-Plate Steel.—A paper by Charles L. Huston, published in the May issue of the *Journal of the Franklin Inst.*, discusses the leading tendencies in the manufacture and use of steel for steam boilers, bridges, etc., namely, the constant effort on the one hand to secure a material of higher tensile strength for carrying higher pressure or heavier loads with, on the other hand, continual vigilance on the part of those upon whom the responsibility of the public safety rests, to require evidences of ductility in the material to avoid the danger point which is approached when the increased tensile strength called for reaches the stage where brittleness results. The author has investigated the general soundness and structure of some of our standard boiler steel ingots, bisecting them vertically and investigating them with a microscope and by chemical analysis, also by rolling some of the half ingots down into plates. The results are given in tables and diagrams, and it is shown that the general character of the segregation in the wide range of sizes and shapes of ingots tested is the same. "As the steel cools in the mold a steadily thickening wall of solidified metal forms against the sides of the mold (which is usually of cast-iron) and numbers of gas bubbles form and rise to the surface in the liquid portion, causing a rising current of metal adjacent to the solidified wall with return downward current in the center. This causes thorough mixing of the portion remaining liquid, but as the carbon and other elements are expelled from the solidifying wall the central liquid portion continually gains in these elements. This action continues until the temperature of the liquid portion falls to a point where its consistency becomes so thick that the gas bubbles cannot rise through it, when circulation ceases, gas formation ceases and segregation ceases and the metal inside this zone of gas bubbles solidifies in a mass of comparatively uniform character." The greatest degree of segregation in the transverse axis of the ingot is adjacent to the zone of gas bubbles, the carbon which was last expelled from the solidified metal being held in the adjoining portion of the central mass of metal which was at the time of too thick consistency to circulate and distribute it, the central vertical axis having less carbon than this gas bubble zone except near the top. Hence, the specimens of plate steel for testing, which, as a rule, are taken from shearings from the outer margin of the plates as rolled, show the softest part of the metal, so that there is much harder metal in the interior. This brings about a very risky state of things. "It would be well if some plan could be adopted now and put into general use which would automatically encourage the use of soft, ductile metal, thus securing increased safety to the traveling public and doing away with a lot of difficulty and contention between makers and the inspectors who represent the users of the metal; whose rejection of quantities of material often occurs simply because it falls slightly below the required minimum limit, though this material, because of its greater ductility, can withstand being worked into the required form for the finished boiler with less risk of weakness developing, and is more worth of carrying the required unit stresses under conditions of service than would be a harder metal of the same thickness. Under present general engineering practice the working stresses allowable are based entirely upon the minimum tensile strength shown, ductility and maximum tensile being introduced only as a check. It would be far better, I believe, if the ductility were introduced as a factor in conjunction with tensile strength to determine the allowable working stresses so that a somewhat lower tensile steel may be used, where it shows a corresponding increase in ductility. In fact, I believe it would result in great improvement over present practice, first, to determine the maximum unit stress and then specify the range of tensile stress allowable in the steel, coupled with a corresponding proper ductility, showing, for instance, given a maximum unit stress of 12,000 lb. per square inch for one class of service specify that the steel shall be allowed a range from 50,000 to 60,000 lb. T. S., provided it also shows a ductility of 1,500,000 lb. divided by the actual T. S. in pounds. This would result in a factor of safety of five with steel of ordinary ductility, but where the ductility showing is high permit a somewhat less factor of safety, and thus encourage the use of soft steels, which, judging from experience of many years, would result in far greater safety to the public service." These suggestions are applicable only to material to be used in tension.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Machining Amorphous Carbon Articles.—P. McN. Bennie, 889,981, June 9, 1907. Assigned to National Carbon Co.

Ordinarily articles of amorphous carbon are difficult to machine owing to the hardness and brittleness of the material. In order to make machining more easy, the inventor softens locally those parts in which the machining tool is to operate without affecting the other portions of the article. For that purpose he causes an arc to play upon the surface of the hard amorphus carbon article from a stationary electrode and manipulates the carbon article, presenting it to the stationary electrode in such manner that the arc locally softens or graphitizes the hard amorphous carbon in those portions or parts which it is desired to remove. The application of this method to forming screw threads is described. Only these parts of the article which are to be machined are thereby graphitized and softened, while the bulk of the article retains the original qualities of the amorphous carbon, especially the high thermal resistance and its physical strength.

Electrolytic Furnaces.

Baryundum.—R. Battistoni and R. Rotelli, 888,956, May. 26, 1908. Appl. filed Jan. 14, 1905.

The product "is composed of a mixture of 10 to 12 per cent BaC_2, 3 to 5 Ba $(CN)_2$, 80 to 85 Ba O. This product of oxycarbide of barium is designated by the name of baryundum. It is distinguished from BaC_2, as well as from Ba O, by its color, its crystalline structure, the easiness with which it is dehydrated and the disengagement of NH_3, which is effected by the hydration of $Ba(CN)_2$." This product is obtained in an electrolytic furnace by electrolyzing with direct current molten barium carbonate to which are added 3 or 4 per cent of exceedingly finely divided carbon. "The carbon acts as a catalytic substance, as a conducting means for the electric current and offers a whole system of bearing surfaces for the regular development of the ions freed by the current." The furnace is first used as an arc furnace, but when the charge is molten the upper electrode is lowered and the furnace is used as resistance furnace. The action is claimed to be that the current decomposes the $BaCO_3$ into Ba O and CO_2. The presence of carbon bases rise to the formation of BaC_2. The latter is a strong reducing agent and a certain quantity of Ba $(CN)_2$ is formed. It is recommended to add to the charge 5 or 6 per cent of a mixture of alkaline salts, as for instance those which are obtained by calcining the mother lyes obtained in the extraction of sugar from the molasses. These salts act as a flux powder.

Electrolytic Processes.

Tin Refining.—O. Steiner, 890,249, June 9, 1908. Application filed Aug. 10, 1907.

The third claim refers to "the method of obtaining tin from crude tin or tin alloys which consists in treating the impure tin as an anode in an electrolyte composed of an alkaline sulfid solution, depositing the tin upon a cathode having a pure tin surface, maintaining the tension between the electrodes at less than 0.2 volts, and keeping the electrolyte quiescent in order to avoid disturbing the mud deposited in the bottom of the bath, removing the anode residues, regenerating the electrolyte by adding sulfer thereto and reusing it to electrolyze fresh anodes." This process of refining tin was described by Dr. Steiner in full in our Vol. V, page 309.

Copper Deposition.—L. Amenabar, 890,887, June 16, 1908. Application filed Nov. 4, 1907.

A sulphuric acid solution of copper is circulated through a system of tanks in which the copper is precipitated in an incoherent granular or flocculent form by using a sufficiently high current tensity. "Practice has demonstrated that a current of 200 amperes and approximately 5 volts per square foot of electrode gives excellent results, both as to economy in time and current consumption." Under these conditions any deposit on the cathode will be of such nature that it may be readily dislodged by shaking the electrodes, washing them, circulating the electrolyte or by a light scraper; when dislodged, the precipitate will pass out of the electrolytic tank with the liquor. The anodes are made of lead or carbon, the cathodes of copper or lead.

Copper Deposition.—M. A. Jullien and E. L. Dessolle, 884,021, April 7, 1908. Application filed April 4, 1907.

Absolutely homogenous copper which has the same resistance and the same tensile strength in every direction and is especially suitable for tubes, plates, etc., is obtained by electrolytic deposition on a revolving cylinder. By special apparatus a polishing action is imparted to the deposit during formation.

Concentrating Nitric Acid.—H. Pauling, 887,226, May 12, 1908. Application filed Aug. 13, 1906.

Dilute nitric acid is subjected to electrolysis in a diaphragm cell and the nitric oxides formed at the cathode are supplied to the anolyte in which they dissolve and are oxidized by the oxygen generated at the anode so as to form nitric acid. The reaction is expressed by the equation $N_2O_5 + H_2O = 2\,HNO_3$.

Aluminium Oxide.—F. W. Morris, 890,084, June 9, 1908. Application filed March 13, 1907.

The object is to produce pure aluminium oxide from clay, etc. The material containing the aluminium, with its common impurities, is first treated with sulphuric acid to form sulphate of aluminium in the same manner as is commonly practiced in the production of alum. The sulphate of aluminium with such of the impurities as are soluble in the acid, is then charged into the anode compartment of an electrolytic cell, the cathode compartment of which is charged with a saturated solution of a chlorine of an alkali metal, such as sodium or potassium, the hydrate of which will, when in excess, dissolve aluminium hydrate. The anode is made of platinum or graphite, the cathode of iron. Chroline is evolved at the anode and alkali hydrate is formed at the cathode with evolution of hydrogen gas." The aluminium and other bases forming impurities of the clay are transposed to the cathode compartment by electrolysis and under the action of the hydrate therein form hydrates of themselves. The hydrates of the iron and other impurities being insoluble in the alkali hydrate are precipitated. The aluminium hydrate which is soluble in the excess of alkali hydrate present under this process, is dissolved and forms an aluminate of the alkali used. The solution of aluminate of the alkali is then siphoned off from the cathode compartment, evaporated to dryness and calcined. This product is then lixiviated in any approved manner to recover the alkali leaving the pure oxid of aluminium as the desired product. The sulphuric acid which has been used to dissolve the aluminium and other bases, and which remains in the anode compartment, is available for treating a further charge of the clay."

Electroplating Apparatus.—W. R. King, 888,093, May 19, 1908. Application filed Dec. 15, 1905; assigned to Hanson & Van Winkle Co.

For plating a large number of small articles, a containing drum of perforated wood is generally used. If the perforations in the wood are too small, the resistance is too high, while if the perforations are too large there is liability of small articles falling out of the drum. The inventor uses a wooden drum with very large holes and in it, a thin, flexible diaphragm of celluloid, vulcanite or the like, about 15/1000-in. thick. It is so arranged that this diaphragm may be slipped into the wooden drum in a convenient way. This diaphragm has a large number of very small holes.

Electroplating Apparatus.—J. T. Daniels, 888,068, May 19, 1908. Application filed July 29, 1907. Assigned to Hanson & Van Winkle Co.

If a number of small articles are to be plated within a re-

volving drum, the inventor uses as cathode a weight suspended by a chain from the shaft in the center of the drum. The articles to be plated surround the weight and chain, and, therefore, make efficient contact with them.

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Dephosphorizing Ore.—J. T. Jones (890,230, June 9, 1908) patents a method for dephosphorizing and reducing iron and manganese ores in one continuous operation. The process is based on the following two observations: "First, when iron or manganese ore is subjected, for a time sufficiently prolonged and while under confinement against access thereto of oxygen, to the action of a hot reducing gas and raised thereby to a temperature which will render the metal constituent sufficiently plastic, without however fusing the silicious constituents, the oxide particles are reduced to metal and caused to agglomerate, forming what may be characterized as sponge. Second, that as the temperature to which the ore is required to be subjected for the above purpose does not reach that necessary to bind phosphorus to the metal, volatiles freed from hydrocarbon fuel by the decomposition thereof and passed through the ore undergoing reduction will readily combine with any phosphoric acid in the ore and carry it off." The process is carried out in a stack furnace into which the ore is charged at the top. The reduction and dephosphorizing goes on in the lower part of the stack, through which a reducing gas is passed upwards (without access of air) from a gas producer. Air is blown into the stack at the top in order to burn the gas and preheat the fresh ore charged into the furnace.

Tungsten Steel.—If tungsten is embedded into steel by throwing tungsten powder on top of the molten bath in an open-hearth furnace, considerable losses are experienced. P. Kemery (887,648, May 12, 1908), recommends to introduce the tungsten or other metal into the bath by enclosing the tungsten powder in a thin steel tube and when this tube is thrown into the furnace just before casting, the tube sinks to the bottom of the bath and the tungsten dissolves in the molten bath.

Precious Metals.

Removal of Gold, Silver and Platinum from Lead Alloys.—A patent of W. Morrison (890,160, June 9), refers to a process for removing within a few hours gold, silver, copper and platinum from lead alloys. The lead alloy of precious metals is placed with zinc and with potassium cyanide as a flux into a crucible and heated to a dull red heat until the zinc approaches the point of volatilization. The heat is then shut off and the crucible cooled, whereby the zinc and precious metals separate from the lead and rise to the top. If the object is to remove the gold only and if no platinum is present, the material with or without the lead (which is at the bottom and can be easily broken off or cut away) is treated with strong nitric acid, which dissolves everything except the gold and lead. The gold is obtained in powdered or granular form separate from the lead. If it is desired to remove both the gold and platinum, the material from the crucible is treated with concentrated sulphuric acid, which dissolves silver, zinc and copper. After washing with hot water and removing the lead mechanically, the remaining material is treated with a dilute solution of nitric muriatic acid, which dissolves the gold and leaves the platinum. Or a potassium cyanide solution may be used. If it is desired to recover the gold, silver, copper and platinum, the material from the crucible is covered with hydrochloric acid or dilute sulphuric acid. This dissolves the zinc leaving all the gold, silver, platinum and copper in powder or granular form, and the lead as solid metal. The acid with the zinc is washed off and just enough nitric acid is added to the residue to dissolve the copper and silver. The silver is precipitated with hydrochloric acid, the solution poured off, the residue washed and the copper precipitated with oxide of calcium. The platinum and gold are then separated as before described.

Miscellaneous.

Valve-Seat Alloy.—An alloy suitable for valve disks, seats or packings, is made, according to H. W. Wortche (887,173, May 12, 1908) of 90 per cent lead and 10 per cent antimony. For a hard composition that will withstand the action of steam, oil, acids, alkalies, etc., at high pressure and at an elevated temperature, an alloy of 80 per cent lead and 20 per cent antimony is preferred.

Antimony.—A patent of J. R. Masson (890,432, June 9, 1908) describes a process for the recovery of pure antimony from ores, concentrates, tailings and slimes. Pulverized ore is treated with a solution of caustic soda or potash, and the antimony is thereby extracted. Sulphuric acid is then added to the solution thereby precipitating antimony sulphide. The precipitate is mixed with clean sand and chloridized by a stream of chlorine gas. The antimony chloride is washed out and the strongly acid liquor is run into vats containing pieces of iron. Pure antimony is thereby precipitated.

On account of limitations of space a large number of abstracts of patents and articles had to be reserved for the regular departments in our next issue.

Blast Separator, Gas Scrubber and Dust Collector.

The Osborne pneumatic blast separator, built by the Osborne Engineering-Manufacturing Company, of New York City, and shown diagramatically in the adjoining illustration, is designed for separating the fines from the tailings and for screening all classes of pulverized material, the separation being regulated to any degree of fineness desired, ranging from 40 to 200 mesh.

In the operation of the machine the material to be separated is fed through a shute and falls upon a rotating disk. The centrifugal force throws out the material, thoroughly scattering it and giving it a whirling motion. A blast of air is simultaneously blown through the material while in suspension, separating the fines from the coarse, throwing the fine material or finished product by short circuit into the dust-collector, where the material is separated from the air, while the air is returned back to the fan to be again used in separating the material.

The air is forced into the separator by means of a blast fan through an air inlet at the bottom. Within the air inlet is mounted a feed disk journaled upon a shaft in a bearing and rotated by bevel gears connected with a pulley which is actuated by any suitable source of power. The gears are enclosed in a casing to protect them from dust. Directly above the disk is an inlet pipe through which the material to be separated or graded is introduced.

A trunk extends downwardly from the bottom of the separator casing and is provided with interior partitions between which and the walls of the trunk, passages are formed adjacent to the side of the trunk. The lower end of the trunk is provided with an outlet for the tailings, and an air-blast pipe enters the trunk and directs a current of air upwardly through the air inlet.

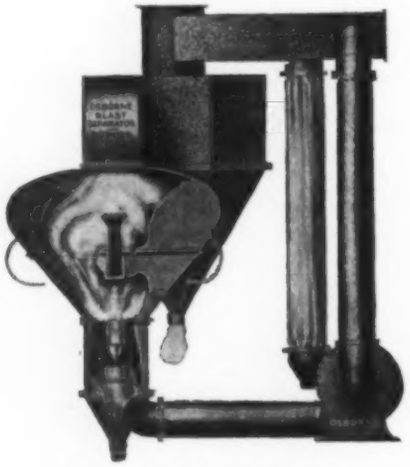
When the separator is in operation the feed disk is rapidly rotated and throws the material delivered by the feed pipe across the air inlet where it is entertained by an upward blast of air and raised into the casing of the separator. The dust and finer particles are immediately carried away into the dust collector by a current of air, while the heavier particles fall direct through the tailing spout or remain suspended for a while in the air current, until they finally come in contact with the walls of the separator, slide down the walls and escape through the outlet.

The degree of fineness of separation can be very easily regulated by adjusting the width of the air-blast passage and therefore the velocity of the air blast (the volume of air blown remaining constant). For this purpose the separator is provided

with two adjustable walls pivoted at their lower extremities and provided with adjusting rods which are pivoted to the walls at their inner ends and pass out through slots in the outer walls of the casing. Teeth on the lower sides of the adjusting rods normally engage the lower ends of the slots so as to hold the walls in adjusted position, and covered plates sliding inways on the walls closely embrace the rods and prevent the escape of air or dust.

When it is desired to adjust the walls, the outer ends of the rods are raised together with the slides, so as to disengage the teeth, and the rods may then be pushed in or pulled out. By this adjustment the width of the air passage between the walls of the separator is varied, and thus the velocity of the air current at this point is varied, and the separator may be made to grade material to different degrees of fineness. When it is desired to carry only the fine particles into the dust collector, the walls are moved apart so as to increase the space between them and reduce the velocity of the air current, and under these conditions only the finest particles will be sustained by the air current and carried into the dust collector. When it is desired to carry the coarse particles into the dust collector, the walls are adjusted closer together.

As has already been mentioned, the number of cubic feet of air used per minute and its carrying capacity remain the same, whatever its adjustment. This is the chief reason for the very large capacity of the Osborne separator in handling a very fine powder.



PNEUMATIC BLAST SEPARATOR.

The relative arrangement of the separator, dust collector and the blower, is such that no material is passed through the blower. The material is delivered to the air blast after it issues from the blower, and is entirely abstracted from the air by the separator and the dust collector before the air is returned to the blower from the latter. This feature is novel in a closed pneumatic separating system, and it is a feature of importance where the material to be operated upon is of an abrasive character, such as might injure the blower by violent contact with the rapidly moving blades, or of a character which would tend to cause it to clog the casing of the blower or to collect upon the arms thereof.

The air pipe which conveys the air from the dust collector back to the fan is provided with equalizing vents connected with cylinders of wire gauze or flume cloth to prevent the escape of dust. The object of these vents is to permit the entrance or escape of air when necessary to equalize the air pressure within and without the apparatus.

It is to be noted that these air vents are so located that the air separator is caused to operate by means of a blast of air under pressure as distinguished from a current of air produced by suction as in other previously proposed devices of this character; that is to say, any vacuum in the air pipe will be then neutralized by the entrance of air through the vents. This is a feature of importance in the construction and conduces to a successful operation of the apparatus.

As material is introduced through the feed pipe and accumulated in the separator, it causes a back pressure and accumulation of air between the blast pipe and separator owing to the resistance offered by the body of material in the separator to the passage of air therethrough, and this results in a partial vacuum in the air pipe and an inflow of air through the vents to restore an atmospheric pressure in the air pipe.

In diminution in weight of material suspended in the separator a reverse action takes place; that is to say, the pressure between the blower and the separator diminishes and an outflow of air occurs at the vents, whence, it is to be seen, that these vents operate as a governor of the amount of air used in the system preventing a congestion of air as may be experienced with separators of the vacuum type.

The manner in which the air is delivered to the separator creates very little friction only, and consequently, requires but little horse-power to separate a ton of finished product. It is found that the average horse-power consumed does not exceed 2 hp per ton of finished product per hour.

Each machine is built large enough to handle a class of material 200 mesh fine, the size of the machine being governed by the number of pounds to be separated per hour and the degree of fineness desired.

For the reasons stated above the Osborne separator is very suitable for handling all classes of abrasive material, such as cement, phosphate rock, limestone barites, etc., where a degree of fineness ranging from 50 to 200 mesh is desired.

The drier the material the better is the separation. But it is a fact that Osborne separators are handling in practice material containing 10 to 12 per cent moisture without any trouble. Thus, the Aluminum Company of America have five Osborne separators installed at their East St. Louis plant, where they are separating bauxite containing 10 to 12 per cent moisture. The average capacity of each machine is eight tons per hour of finished product that will screen 90 to 100 mesh fine.

Another very good machine of the Osborne manufacture is the Osborne water spray gas scrubber and dust collector. This machine is largely used in manufacturing plants throughout the country to do away with the smoke nuisance. Not only is the smoke nuisance abolished by it, but all the carbon in the smoke is collected and saved and may be used in the furnaces.

Other uses of this machine are for the collecting of the fine dust from calcining furnaces, and for the washing and collecting of gases from roasting ovens in concentrating plants, leaving the air escape into the atmosphere in a practically pure state.

Osborne gas scrubbers have been installed at the works of the Aluminum Company of America, East St. Louis, Ill.; the S. D. Warner Paper Co., Cumberland Mills, Maine; the Pennsylvania Salt Manufacturing Co., Natrona, Pa.; the Springfield Gas Co., Springfield, Mass., and in many other large plants.

Missouri River Development.

The Missouri River power development is an interesting example of progressive engineering activity in the Western mountainous mining and metallurgical country.

Over twelve years ago a wooden dam was built across the Missouri River at Cañon Ferry, by the Helena Power Transmission Co., Helena, Mont., and the impounded waters used to operate four 750-kw turbines direct connected to electric generators. The voltage of the alternating current from this station was stepped up to 11,000 volts and transmitted 18 miles to Helena to be used in the mines and smelters there.

From the very first the enterprise proved a success. The original company, later enlarged and reorganized as the Missouri River Power Company, undertook to transmit power to

Butte, 80 miles away, for use in the mines in that section. To this end six new 750-kw generators with their water-wheels were added to the original equipment. The first transmission line, using as high as 50,000 volts, was built from Cañon Ferry to Butte and was very successful. In completing this plant the waters of the river were backed up for 18 miles, giving a fall of 30 ft. at the dam.

As the demand for power grew, the present company, the Helena Power Transmission Company, was formed, taking over the equipment of the older companies and building a new dam below the Cañon Ferry at Hauser Lake, where four 2800-kw waterwheel-driven alternators were installed.

Power from these plants is carried over double lines to Helena, Butte and Anaconda, the last named place being over 100 miles from the generating points. Practically 16,000 horse-power is used to operate the mines at Butte. The Helena Street Railway system is operated from this source and the Great Washoe smelter of the Anaconda Copper Company at Anaconda is another heavy consumer.

The electrical equipment of this great smelter, built by the Allis-Chalmers Company, Milwaukee, is unique among all plants of its kind so far built in that it includes four of the largest induction motors installed west of Niagara and was the first smelter in the country to be driven by electric power exclusively. The concentration building is 600 ft. long. The jigs, tables, etc., are driven from a main-line shaft 500 ft. long. Two induction motors are installed in each half of the mill and connected to the main shaft by rope-drive and friction-clutch pulleys. Each motor has an output of 1200 horse-power at 360 r.p.m. synchronous speed. Connection is made to the main shaft by 18 2-in. ropes.

These large motors are notable not only on account of their large capacity, but also because of their having squirrel-cage rotors, something unusual in motors of this size. Their guaranteed full-load efficiency is 91 per cent and full-load power factor 92 per cent. Squirrel-cage motors were chosen for this installation because the conditions under which they have to start are favorable and also because of the higher power factor of this kind of motor as compared with the wound rotor type.

In addition to the four large motors there is also provided a 200-hp, variable-speed, 60-cycle, 2,080-volt induction motor for operating the pumps in the mill.

This motor is of standard type with wound rotor and collector rings for the insertion of resistance in the secondary. The normal speed is 450 r.p.m. and can be reduced to 225 r.p.m. by means of a grid type resistance furnished with the motor. Allis-Chalmers Company has also furnished for this plant three synchronous motor-generator sets of 300-kw output each, and one small induction motor-generator set for starting and exciting the synchronous sets. The 300-kw sets are driven by 12-pole, 2080-volt, 60-cycle synchronous motors and run at a speed of 600 r.p.m. The direct-current generators for these sets are compound wound for 550 volts and are easily able to carry 50 per cent overload for two hours without heating more than 55 deg. C. and without sparking. At normal full load the temperature rise does not exceed 35 deg. C in any part. The sets have three bearings and the stator of the synchronous motor is arranged to slide sideways on the base to give access to the field and armature windings. These units are to operate crane motors throughout the plant and also furnish power for other purposes.

Formerly all the power required by the Washoe smelter, which has been equipped throughout with electric drive, was obtained from steam engines, and a certain amount of steam power will probably always be used, as some of the steam boilers utilize the heat contained in the waste gases from the furnaces. However, this power, obtained as a by-product, is not nearly sufficient to operate the whole plant, and all additional power is now supplied as above stated by current transmitted from the Missouri River.

Columbia University.

Mr. Arthur L. Walker, who retired on January 1, 1908, from his connection with the American Smelting & Refining Company as consulting engineer and member of the Board of Directors, and has since been engaged as general consulting engineer in New York City, has been appointed professor of metallurgy and administrative head of the department of metallurgy at Columbia University. His duties will begin on July 1, and he will take personal direction of the instruction in non-ferrous metals and electro-metallurgy and metallurgical design. Mr. Walker is one of the most distinguished metallurgical engineers of this country.

Prof. Henry M. Howe will continue to deliver his lectures on iron and steel, as heretofore.

In 1907 Columbia University revised the entrance examination requirements for its Schools of Mines, Engineering and Chemistry by co-ordinating them with the programmes of the best secondary schools. By the adoption at the same time of a uniform programme of studies for the first year in all courses students were no longer compelled to make up their minds at the outset as to the particular course they desired to take. Following these steps has come the co-ordination and revision of the three subsequent years of each of the courses. This revision will go into effect on July 1, 1908.

In the first place, the programmes have been thoroughly co-ordinated by cutting out such duplication of instruction as had grown up in the development of the several departments.

Secondly, the work in many subjects has been made more intensive, and, as a result, it has been possible to reduce the total number of attendance hours in such courses.

Thirdly, new courses have been arranged in gas power and steam power machinery, and exercises in alternating-current laboratory practice have been introduced in the third year of the course in mining engineering. This work has also been introduced into the course in metallurgy, and, in addition, work in mining law and in hydraulics.

A New Manganese-Silicon Alloy.

Silicon and manganese—the two chief and most effective elements used as a "physic" in the steel industry—have generally been employed in form of ferrosilicon, ferromanganese, spiegeleisen or silicon-spiegel. If made in the blast furnace, these alloys (with the exception of ferromanganese) cannot be produced with a high percentage of the desired element. Blast-furnace alloys also contain a large percentage of carbon.

Only with the advent of the electric furnace the production of high-percentage ferroalloys, very low in carbon, has become possible. But although ferrosilicon and ferromanganese, containing as much as 90 per cent of silicon and manganese respectively, have been produced, thus enabling the steel-maker to introduce a desired amount of these elements into the steel in the smallest bulk, it has not in actual practice been found desirable or economical to use ferrosilicon over 50 or 60 per cent or ferromanganese over 80 per cent; consequently, when it is desired to add any considerable amount of manganese or silicon to the steel, it is necessary to add a somewhat large quantity of these alloys to the bath or ladle.

These large quantities of additions exert an appreciable chilling effect on the metal when made in the ladle after tapping, or, on the other hand, when made in the furnace, the loss by oxidation is large. This loss is most pronounced and serious in the case of the manganese, and it therefore becomes necessary to add a large excess, which, besides being expensive, raises the carbon in the steel.

To overcome these difficulties there has recently been put on the market by Messrs. Roberts, Evans & Woodhead, of Liverpool, England, a high-grade ferrosilicon-manganese alloy which is a product of the electric furnace, and deserving of a more extended use than has hitherto been accorded it. The alloy

can be obtained in several grades, and in such a high state of purity as regards carbon, sulphur and phosphorus as is highly desirable from the steel-makers' standpoint.

The following are a few typical analyses of the material delivered at more than one steel works:

Silicon.....	24.90	25.02	28.56	25.51
Manganese.....	67.73	68.64	63.45	69.26
Phosphorus.....	0.091	0.021	0.065	....
Carbon.....	0.176	0.160	0.150	0.180
Sulphur.....	0.012	0.010	0.019	....

It will be readily understood that in cases where it is desired to add both silicon and manganese to the steel a very much less quantity of alloys has to be added to the metal in ladle or bath. The use of the ferrosilicon-manganese alloy presents the further advantage that in addition to being practically free from carbon and other impurities, only half the quantity of these impurities are introduced to the steel, as compared to the case of separate additions of ferrosilicon and ferromanganese, even if it were possible to obtain those alloys of an equal degree of purity.

It is worthy of note that the decreased amount of alloy necessary in the case of the ferrosilicon-manganese is not due only to the fact that the silicon and manganese are combined with a smaller amount of iron, but also due to the fact that the loss of manganese, due to oxidation, is also very much less. The silicon acting as an energetic deoxidiser is first attacked by the occluded gases in the steel, and consequently the manganese is practically all retained by the metal, instead of going to the slag, as is the case when ferromanganese and ferrosilicon are added separately.

Some experiments were recently carried out in open-hearth furnace to determine to what extent the oxidation loss was reduced, and it was found as a result that, when using the new alloy, although the loss of silicon was practically the same, the loss of manganese was only about one-third of what it was when adding the silicon and manganese alloys separately. For instance, in one case, ferrosilicon-manganese was added to a charge in such quantity as to theoretically give 1.035 per cent of manganese in the metal. The finished steel on analysis gave 0.946 per cent of manganese.

Another charge worked under exactly similar conditions as to time and condition of slag, and from the same pig iron and scrap, had added to it ferromanganese in quantity to give almost exactly the same theoretical amount of manganese (1.05 instead of 1.035) together with an amount of ferrosilicon containing a similar quantity of silicon to that contained in the ferrosilicon-manganese alloy used in the other charge. The finished steel on analysis gave only 0.82 per cent of manganese, showing a loss of 22 per cent against only 8.4 per cent in the charge where the new alloy was added.

It is found that the silicon not only protects the manganese from oxidation, but that its action on the metal is very much more complete, giving good solid metal, quite free from all blow-holes. The result on the finished material is also appreciable in the results of the physical tests, the ductility especially being improved, and this at a reduced cost for "physic." The results of careful and extended trials in the use of the new alloy for the manufacture of steel castings, forgings and tyres, and miscellaneous material for special purposes, show that, taking the prices of the various alloys, there appears to be a substantial saving in favor of the use of the ferrosilicon-manganese alloy.

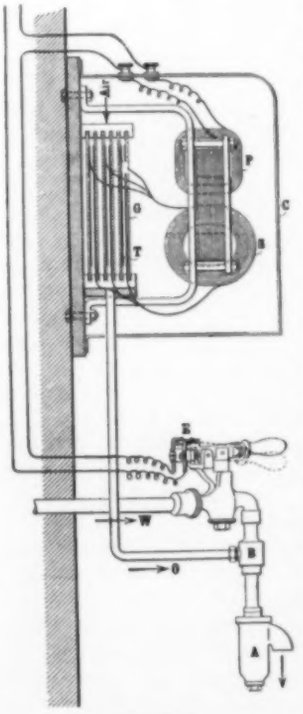
The silicon-manganese alloy is specially suitable for use in the manufacture of steel castings, forgings and tyres, plates and bars, and all similar materials in which it is desired to obtain the maximum soundness, toughness and resistance to wear and abrasive action. The high degree of purity in which it is put on to the market enables it to be used in the production of the very finest special steels, more particularly mild steel.

Water Sterilization for House Use.

In a recent issue of Lond. *Electrical Engineering*, we find a description of a commercial apparatus sold in England by the Lahmeyer Electrical Company and called the Otto ozonizer. The apparatus is of the type used for installation in private houses for treating the drinking water instead of filters, and consists of a small transformer and ozonizer enclosed in a case a little over a foot square. A special tap and emulser in which the ozone is mixed with the water are also provided. If the supply is continuous-current, a small rotary converter, four or five inches in diameter, must be used to convert to alternating current. The principle of the ozonizer is best explained with the aid of the adjoining diagrammatic sketch.

In the upper part of the sketch are shown the transformer and ozonizer in the metal case C. P is the primary winding of the transformer, which is supplied with current at from 100 to 250 volts, according to the voltage of the supply mains or the converter. S is the secondary winding of very fine wire, which supplies current to the ozonizer plates at a pressure of about 15,000 volts. The ozonizer proper consists of six or more glass plates (G) supported on a grooved bracket at the bottom, and by grooved slips at the top and sides. Three pairs of plates are shown in the sketch. The inner sides are each provided with a coating of tinfoil (T), the opposing coatings being connected in parallel with the secondary winding of the transformer. The distance between the coatings is about one millimeter, and the layer of air is broken down so that a continuous brush discharge takes place between the coatings. The oxygen in the air passing between the coatings is converted by the action of the brush discharge into ozone.

The air enters at the top and sides of the battery of plates, and is sucked down through the opening provided in the lower bracket into the ozone pipe by the action of the water at the junction B. The water carries the ozone down with it into the emulser A, in which the two are mixed together and the water thoroughly sterilized. As the transformer need be working only when water is being drawn, the primary switch is interconnected with the water tap as shown at E in the sketch. When the water is turned on, the primary winding, or, in the case of a continuous-current supply, the converter, is connected to the supply mains and in a few seconds thoroughly sterilized water is issuing out of the emulser at the rate of 60 gallons per hour. As the apparatus requires little more power than that corresponding to the no-load losses of the transformer, the consumption of energy is very low.



OZONIZER.

When first drawn, the water smells strongly of ozone, but in a few seconds the ozone has gone, leaving the water fresh and pure. The apparatus is said to supply some 8 to 10 grains of ozone per cubic meter of air, although much less would be sufficient to perfectly sterilize the water with which it is brought in contact.

It is stated that in several French towns the Otto system of sterilization of water by ozone has been or is being adopted

on a large scale. In this case the ozone is pumped into mixing tanks and these are filled with pebbles in order to insure that the water is thoroughly broken up and mixed with the ozone. Some of the larger installations are stated to deal with several millions of gallons of water daily.

Equipment of a Large Zinc Oxide Plant.

The oxide plant of the Ozark Zinc Oxide Works, at Coffeyville, Kan., said to be the most complete of its kind in the West, had a capacity of 60 tons of ore per day, later increased to 125 tons of ore per day, and is adapted to the manufacture of either zinc oxide or leaded zinc. The plant, which was extensively enlarged in 1907, uses a modification of the old Wetherill process and, being divided into two separate units, one can be employed independently of the other. Since the Ozark Company is controlled by the Sherwin Williams Company, paint and varnish makers, of Cleveland, Ohio, its output of pigments is very largely used in the Cleveland company's product.

Ore is unloaded from the mine car into a 20-in. x 10-in. Blake crusher which discharges into a Gates elevator and is carried to the top of the building and discharged into a revolving screen, having ⅝-in. openings, the oversize from which goes to a set of 36-in. x 12-in. crushing rolls on the second floor. The ⅝-in. material is discharged into a second trommel with ¼-in. openings, the oversize going to another set of 36-in. x 12-in. crushing rolls on the first floor, after which it is returned to the crushing rolls on the second floor, after passing to a mixing drum which discharges into a Vezin sampler. The crushing machinery, including elevators and screens, was furnished by Allis-Chalmers Company, Milwaukee. A 75-hp induction motor drives the crushing section. Storage bins for crushed ore are arranged to be emptied from beneath into cars.

The roasting is done in two five-hearth Allis-Chalmers McDougall furnaces, each 18 ft. x 16 ft. 6 in. high, and driven by a 25-hp induction motor. At a later date two six-hearth McDougall furnaces were added, each 18 ft. x 19 ft. high. They are fired by gas, ordinary 1-in. x 2-in. mixers being used for the furnaces. These furnaces have a capacity of from 25 to 35 tons each per day, but the question of capacity can only be approximated on a new proposition.

The composition of the ore is not a true index to its calorific values. Two ores may be of the same general composition and yet be at great variance in heat values contained, or the amount of heat necessary to be added in order that they may be roasted to a given percentage in sulphur. For example, the Butte ores have the same general characteristics one with another, yet the roasting capacities of these furnaces varies with the different plants. At one place where there are 20 McDougalls installed the amount of ore treated per furnace is 35.9 tons of wet material, 9.7 moisture, and roasted down to 8 per cent in sulphur. At another plant where there are two furnaces installed working under almost identical conditions, they are roasting only 30 tons. This reduction in tonnage is principally due to the combination of the sulphur contents.

In the furnaces installed at Coffeyville, the ore is taken from the bins in two-ton cars, is elevated to the tops of the furnaces and discharged into the large hoppers from which the furnaces are fed. The ore deposited automatically onto the roasting hearths, passes through the furnace and after roasting is discharged into cooling bins from which it is taken to the oxidizing furnaces. After roasting the sulphur content of the ore is reduced to 3 per cent only.

There are two blocks of oxidizing furnaces each containing 18 furnaces 6 ft. x 12 ft. The blast is furnished by two fans driven by a 30-hp motor, is carried to the furnaces by a large underground conduit and discharged under the grate. The furnace is controlled individually by means of a drop grate.

The fumes are drawn away from the furnaces by a large exhaust fan located in the bag room. The fume first enters a combination chamber when the carbon is all burned out and the dirt is allowed to settle. It is then fanned through 600 ft. of cooling pipe to lower its temperature. Then it enters the fan and is driven to the bag room. The fume first enters the laterial pipe and from thence is distributed to 18 pipes each with 17 hoppers on which short bags are tied reaching to the floor. Oxide is shaken down into the short bags, which are removed every 24 hours and dumped into a conveyor which carries them to the packing room. Oxide is packed 400 pounds in a barrel.

The power plant comprises two 180-hp boilers fired by gas, and one 250-hp Corliss engine direct-connected to an Allis-Chalmers alternating-current generator of 150-kw capacity. The coal used is practically all Arkansas semi-anthracite. The design for this plant was laid out by Allis-Chalmers Company, Milwaukee.

Notes.

E. J. Lavino & Co., of Philadelphia, dealers in ores, metals and ferro alloys, have sent us a very useful brass-trimmed desk rule.

The Moechel & Lowther Engineering Co. have established a consulting office and testing laboratory for chemical engineering work at 1110 Wyandotte Street, Kansas City, Mo.

The American Process Company, manufacturers of mechanical drying apparatus for drying all classes of ores, chemicals, etc., have moved their offices from 62 to 68 William Street, New York City.

Radiation Pyrometer.—An interesting illustrated Franklin Institute paper by Dr. C. B. Thwing, published in the May issue of the *Journal* of this institute, discusses his new radiation pyrometer, which was described in our February issue.

Detroit Foundrymen's Convention.—A number of Detroit members of the American Foundrymen's Association recently held a meeting and formed the Detroit Foundrymen's Association. Mr. W. M. Corse, of the Detroit Lubricator Co., was elected president, Mr. A. P. Henry, of the Henry Standard Pattern Works, secretary.

Getting Ready for Prosperity—Under this suggestive title a booklet has just been issued by Dr. Fred. J. Maywald, consulting chemist and successor to the late Prof. Peter T. Austen. The booklet emphasizes that now is the time to get ready for prosperity and shows how the chemist can assist the manufacturers to do this. The book is sent to interested parties on request.

The Dow Chemical & Manufacturing Company, of Mansfield, Ohio, call attention to the fact that they are prepared to make all kinds of nickel castings for all purposes, and have in the past done considerable work in this line. Castings are made according to specifications and are not limited in size or shape. This company also furnishes complete electroplating outfits and supplies, including dynamos, tanks, anodes, chemicals and polishing machinery.

Oildag.—Mr. E. G. Acheson has transferred to the Acheson Oildag Company his patents and trade-marks covering his latest important and valuable products—oildag and aquadag. Oildag has already obtained wonderful popularity as a gas engine lubricant, as its use makes possible a fifty per cent reduction in the oil consumption, at the same time greatly increasing the available power of the engine by decreasing the friction and increasing the compression, also quieting the engine and making it run like velvet. Thus it effects economy while improving results. Oildag is also valuable in the operation of electric lighting plants. It is a mixture of deflocculated, unctuous Acheson graphite mixed with oil, put up in tubes and cans for charging one, five and ten gallons of mineral oil. The Acheson Oildag Company has established offices and works at Niagara Falls, N. Y., and has elected the following officers: President, Mr. Edward G. Acheson, Jr.; secretary, Mr. W. H. Arison; treasurer, Mr. A. M. Williamson.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES.—(*Continued*).

No. 236,478, Jan. 11, 1881, Clinton M. Ball, of Troy, and John H. Guest, of Brooklyn, N. Y.

Resistance type, for carbonizing electric-lamp filaments. The articles to be carbonized are imbedded in a resistor of finely-pulverized carbon, in a vertical clay tube surrounded by ashes. The upper terminal is a plug, loosely resting on the resistor and sinking as the carbonized articles shrink.

No. 248,437, Oct. 18, 1881, Thomas A. Edison, of Menlo Park, N. J.

Resistance type, for carbonizing filaments. The resistor is a U-shaped horizontal vessel, of carbon, nickel or platinum, with a removable cover for introduction of the filaments. The vessel is filled with or surrounded by a gaseous carbon compound, e. g. naphthalene vapor.

No. 282,964, Aug. 14, 1883, J. L. Delaplaine, Joseph G. Dendrickson, and Francis H. Clamer, of Philadelphia, Pa.

Charge-resistance type. The furnace is a rectangular fire-brick structure, which is filled with tin-scrap or galvanized iron. Electric terminals pass through the walls into contact with the scrap, which is heated by resistance to such temperature that the tin and lead, or zinc, melt and run to the bottom, where they are drawn off. Any tin which does not melt is oxidized.

No. 319,945, June 9, 1885, Eugene H. Cowles and Alfred H. Cowles, of Cleveland, Ohio.

Charge-resistance type. Resistor of pulverized electric-light carbon or crystalline silicon. Two forms are shown: One is a horizontal cylinder of "silica," imbedded in charcoal or mineral wool. Zinc ore to be smelted is mixed with the resistor. One end of the cylinder is closed by a carbon-plate terminal; the other end by a graphite crucible with a perforated bottom, serving as a terminal and condenser for zinc-fumes. The second furnace is a rectangular fire-brick chamber, covered with a fire-clay slab having venting-openings. The terminals are vertical carbon plates, near the ends of the vessel. The resistor is a core extending between the plates and surrounded by charcoal, silica, corundum or lime. The ore to be reduced, e. g., corundum, cryolite, clay, or compounds of silicon, boron, calcium, manganese or magnesium, are mixed with the resistor. The reduced metal may remain in the interstices of the core or melt and run to the bottom.

No. 335,059, Jan. 26, 1886, Eugene H. Cowles and Alfred H. Cowles, of Cleveland, Ohio.

Charge-resistance type. Rectangular chamber of fire-brick, covered with a clay slab. The walls are lined with finely-pulverized charcoal which has been soaked in water impregnated with lime, the resulting coating of calcium oxide rendering the charcoal more resistant to heat and the flow of electric current. Or the charcoal may be soaked in water containing gelatinous aluminum hydroxid.

No. 360,144, March 29, 1887, Eugene H. Cowles and Alfred H. Cowles, of Cleveland, Ohio.

Charge-resistance type. The terminals are vertical superposed carbon tubes, the charge being fed into the top of the upper tube and the product from the bottom of the lower tube. The tubes are surrounded by a filling of pulverized charcoal, or lime and carbon, retained by walls of fire-brick, silica or lime. The charge is fed by a vertically-reciprocating carbon bar, with lateral projections, or by a rotary screw, in the upper electrode. The rate of feed and thereby the resistance of the furnace is automatically regulated by an electrically-controlled motor.

No. 390,964, Oct. 9, 1888, Abraham T. Hay, of Burlington, Iowa.

Induction type. Surrounds a blast furnace with superposed coils of copper wire, insulated with Manila paper and sodium silicate. The air for the blast is heated by passing between the iron furnace-shell and the coils. Electric currents are passed through the separate coils, whereby the charge of the furnace "forms a magnetic core" which "will have its polarity repeatedly changed owing to the fact that the sections are separate magnets." The inflowing air is also said to be magnetized.

No. 391,034, Oct. 16, 1888, Henry H. Eames, of Baltimore, Md.

Resistance type. Drives off the sulphur and phosphorus from iron ore by placing it in vertical externally-heated retorts and passing an electric current through it. The retorts are of brick or iron lined with fire-clay. The electrodes are segmental metallic plates extending down along opposite sides of each retort. The ore is said to be heated and electrolyzed, the elimination of the phosphorus and sulphur leaving spongy iron.

No. 428,378, May 20, 1890, Edward A. Colby, of New Haven, Conn.

Induction type. A charge of metal to be melted and refined, for example platinum in the form of scraps, is placed in a deep, annular groove, formed in a block of fire-clay or lime. This charge constitutes the primary coil. Around the block is the secondary winding, of wire insulated with asbestos and wound on a slate spool. A core of iron wires extends through the open center of the block and around the coils. The furnace has an external brass casing, supported on trunnions, and an air-tight cover with pipes for withdrawing air and introducing gases and an observation opening closed by glass. An ingot mold depends from the cover, in such position that the molten metal flows into it when the furnace is turned on its trunnions.

Nos. 428,379 and 428,552, May 20, 1890, Edward A. Colby, of New Haven, Conn.

Induction type. Similar to the preceding, except that the lower part of the groove which receives the metal is lined with a trough of platinum or nickel, into the bottom of which leads a pipe for supplying gases.

No. 436,519, Sept. 16, 1890, Mark W. Dewey, of Syracuse, N. Y.

Resistance type. The resistor is a body of powdered or granulated carbon, coal, metal, or metal mixed with carbon, fire-brick, sand or pumice stone. It is supported in an open box of fire-brick or asbestos, containing terminal-plates of metal or other material. The ends of the box may be widened, to increase the contact-surface of the resistor and terminals. The resistance may be locally increased by an intermediate block of fire-brick resting on the box and partially subdividing the resistor. The resistor may consist of oil or a metallic liquid. The furnace is especially intended for heating metallic bars and blanks to be welded or worked.

No. 482,586, Sept. 13, 1892, Thomas Parker, of Newbridge, England.

Arc or resistance. The furnace is a vertical rectangular shaft. Three pairs of opposed horizontal electrodes pass through the side walls, at the bottom. These electrodes may be blocks of carbon fixed in metal casings, or may be of metal, with internal water-passages. The electrodes are automatically adjusted to maintain a uniform current, notwithstanding the varying resistance of the charge, by electrically varying the applied electromotive force. With alternating-current machines, the magnets of the exciter are controlled; with constant-current machines, the main magnets. Beneath the electrodes are starting-pencils of metal or carbon, which are initially pushed together to strike arcs or to bring the lower part of the charge to incandescence. The charge contains coke, which, coming in contact with the electrodes, maintains incandescence. Finely-divided carbon is supplied through side openings to the exposed ends of the electrodes, to maintain them in working order.

No. 494,585, April 4, 1893, Willis Mitchell, of Malden, Mass.

Resistance type. The furnace is a crucible, consisting of two sections of plumbago or metal supported by a U-shaped strip of asbestos or fire-clay, cemented thereto. Terminal plates, carried by a handle, are clamped onto the carbon sections.

No. 494,586, April 4, 1893, Willis Mitchell, of Malden, Mass.

Resistance type. The furnace is a crucible, consisting of two end sections molded from a mixture of graphite 4 parts and fire-clay 1 part, and an intermediate section of fire-clay. Cop-

per terminal-plates are imbedded in the end sections. A resistance bed of pulverized graphite is placed in the crucible, surrounding the article to be heated, which may be a small stone crucible or a horizontal muffle. The small crucible may be carried by an integral with the intermediate section.

NEW BOOKS

INDUSTRIE DES METAUX SECONDAIRES ET DES TERRES RARES. By Paul Nicolardot. 448 pages, 37 illustrations. Bound in cloth. Price, 5 francs. (Retail price in New York, $1.25.) Paris, France: Octave Doin.

THE METALLIC ALLOYS. By W. Theodore Brannt. (A practical guide for the manufacture of all kinds of alloys, amalgams and solders used by metal-workers; together with their chemical and physical properties and their application in the arts and the industries; with an appendix on the coloring of alloys and the recovery of waste metals.) Third edition, thoroughly revised and enlarged. 579 pages, illustrated by 45 engravings. Bound in cloth. Price, $3 net. Philadelphia, Pa.: Henry Carey Baird & Co.

THE IMPORTANCE OF THE MINING INDUSTRY TO THE INDUSTRIAL AND COMMERCIAL LIFE OF A NATION. By Harry Ja. Cantwell. An address delivered before the American Congress at Joplin, Mo. 8 pages. Paper cover, gratis. St. Louis, Mo.

MINES AND MINERALS OF THE BRITISH EMPIRE. By Ralph S. G. Stokes. (Being a description of the historical, physical and industrial features of the principal centers of mineral production in the British dominions beyond the seas.) 423 pages, illustrated. Bound in cloth. Price, $4.20 net. New York: Longmans, Green & Co.

The bulk of this volume is based upon observations made and data collected during a tour of the British Empire extending from Jan., 1906, to the beginning of 1908. On this journey, a course was pursued from South Africa through Ceylon, India, Burma, Malay Peninsula, Australia, New Zealand, and Canada, etc.

SYNTHETIC INORGANIC CHEMISTRY. By Arthur A. Blanchard, Ph.D. A laboratory course for first-year college students. First edition. 89 pages. Cloth binding. Price, $1. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

LABORATORY OUTLINE FOR DETERMINATIONS IN QUANTITATIVE CHEMICAL ANALYSIS. By Albert F. Gilman. 88 pages. Bound in cloth. Price, 90 cents net. Easton, Pa.: Chemical Publishing Co.

LEATHER TRADES CHEMISTRY: A PRACTICAL MANUAL ON THE ANALYSIS OF MATERIALS AND FINISHED PRODUCTS. By S. R. Trotman. 300 pages. Bound in cloth. Price, $4.50 net. Philadelphia: J. B. Lippincott & Co.

THE SUGAR REFINING INDUSTRY IN THE UNITED STATES: ITS DEVELOPMENT AND PRESENT CONDITION. By Paul L. Vogt. 135 pages. Bound in cloth. Price, $1.50. Philadelphia: John C. Winston Co.

THE STRUCTURE OF THE COTTON FIBER IN ITS RELATION TO TECHNICAL APPLICATIONS. By F. H. Bowman. 490 pages, illustrated. Cloth binding. Price, $2.75 net. New York: Macmillan Co.

THE PURCHASE OF COAL UNDER GOVERNMENT AND COMMERCIAL SPECIFICATIONS ON THE BASIS OF ITS HEATING VALUE; WITH ANALYSES OF COAL DELIVERED UNDER GOVERNMENT CONTRACTS. By D. T. Randall. 27 pages. Paper binding. Price, 15 cents.

POWER GAS PRODUCERS; THEIR DESIGN AND APPLICATION. By Philip W. Robson. 239 pages, 105 illustrations. Bound in cloth. Price, $3 net. New York: Longmans, Green & Co.

HYDRAULICS. By F. C. Lea. 548 pages, illustrated by tables and diagrams. Bound in cloth. Price, $5. New York: Longmans, Green & Co.

HYDRAULIC ENGINEERING. By Gardner D. Hiscox. (A practical treatise on the properties, power and resources of water for all purposes, including the measurement of streams, the flow of water in pipes or conduits; the horse-power of falling water; turbine and impact water-wheels; wave motors; centrifugal, reciprocating and air-lift pumps, etc. 320 pages, illustrated.) Bound in cloth. Price, $4. New York: Norman W. Henley Publishing Co.

MECHANICAL ENGINEERING FOR BEGINNERS. By R. S. McLaren. 294 pages, with numerous illustrations. Bound in cloth. Price, $1.75 net. Philadelphia: J. B. Lippincott & Co.

MACHINE DESIGN, CONSTRUCTION AND DRAWING. By H. J. Spooner. A text-book for the use of young engineers. 711 pages, with 86 tables and over 1400 figures. Bound in cloth. Price, $3.50. New York: Longmans, Green & Co.

PROFIT-MAKING IN SHOP AND FACTORY MANAGEMENT. By C. U. Carpenter. 146 pages. Bound in cloth. Price, $2. New York: Engineering Magazine.

FIRST PRINCIPLES OF THEORETICAL MECHANICS. By L. G. French. 37 pages, illustrated. Paper cover. Price, 25 cents. New York: Industrial Press.

PRINCIPLES AND PRACTICE OF ARTIFICIAL ICE MAKING AND REFRIGERATION. By L. M. Schmidt. Comprising principles and general considerations; practice as shown by particular systems and apparatus; insulation of cold storage and ice houses, refrigerators, etc.; useful information and tables. Third edition, revised and enlarged. 437 pages, 205 engravings. Bound in cloth. Price, $3. Philadelphia, Pa.: Philadelphia Book Co.

PRACTICAL PAPER MAKING: A manual for paper makers and owners and managers of paper mills, to which are appended useful tables, calculations, data, etc. By G. Clapperton. Second revised and enlarged edition. 236 pages, illustrated. Bound in cloth. Price, $2.50. New York: D. Van Nostrand Co.

CELLULOID: Its raw material, manufacture, properties and uses; a handbook for manufacturers of celluloid and celluloid articles, and all industries using celluloid; also for dentists and teeth specialists. By F. Böckmann. Translated from the third revised German edition by Charles Salter. 123 pages, illustrated. Bound in cloth. Price, $2.50. New York: D. Van Nostrand Co.

DEVELOPMENT AND ELECTRICAL DISTRIBUTION OF WATER POWER. By Lamar Lyndon. 323 pages, illustrated. Bound in cloth. Price, $3 net. New York: John Wiley & Sons.

NOTES ON THE CONSTRUCTION AND WORKING OF PUMPS. By E. C. R. Marks. Second enlarged edition. 267 pages, illustrated. Bound in cloth. Price, $1.50. New York: D. Van Nostrand Co.

INTRODUCTORY COURSE OF CONTINUOUS-CURRENT ENGINEERING. By A. Hay. 337 pages, illustrated by diagrams. Bound in cloth. Price, $2.50 net. New York: D. Van Nostrand Co.

PRACTICAL PHYSICS. By W. S. Franklin, C. M. Crawford and B. Macnutt. A laboratory manual for colleges and technical schools, with figures and diagrams. Vol. I, Precise Measurements; Measurements in Mechanics and Heat. 173 pages, illustrated. Bound in cloth. Price, $1.25 net. Vol. II, Elementary and Advanced Measurements in Electricity and Magnetism. 160 pages, illustrated. Bound in cloth. Price, $1.25 net. New York: Macmillan Co.

THE CONDITIONS AND TENDENCIES OF TECHNICAL EDUCATION IN GERMANY. By Arthur H. Chamberlain. 108 pages. Bound in cloth. Price, 50 cents. New York: C. W. Bardeen.

TECHNOLOGICAL DICTIONARY IN FRENCH, ENGLISH AND GERMAN. Edited by A. Tolhausen. New edition revised by L. Tolhausen in three volumes. Vol. I (French), 821 pages, suppl. 197 pages; Vol. II (English), 960 pages, suppl. 77 pages; Vol. III (German), 851 pages, suppl. 189 pages. Bound in cloth. Price, $2.75 net. New York: Macmillan Co.

THE WESTMINSTER SERIES. Price of each volume, $2. New York: D. Van Nostrand Co.

India Rubber and Its Manufacture. By H. L. Terry.

Electric Power and Traction. By F. H. Davies.
Liquid and Gaseous Fuel. By Prof. V. B. Lewes.
Coal. By James Tonge.
Iron and Steel. By J. H. Stansbie.
Town Gas for Lighting and Heating. By W. H. Y. Webber.

BOOK REVIEWS.

Lead Refining by Electrolysis. By Anson Gardner Betts. 8vo., illustrated by plates and figures, 403 pages. Price, $4. New York: John Wiley & Sons.

As this is the first treatise on this subject in any language, we heartily congratulate its author on his achievement. Satisfactory above all things is the fact that the man who has created the industry of electrolytic lead refining, takes on himself to tell us all about it. He says, in truly fine vein, in the preface: "The contained information is the result of a number of years of study, experiment and practical work, and is published in the hope that it will save those who may be interested in lead refining practice or its improvement the repetition of experiments already performed and give them the benefit of the work already done by others and myself."

The eleven chapters deal, respectively, with the study of the suitable electrolytes, deposition of antimony from the solution, manufacture of the fluosilicic acid, choice of system, refinery construction, operation and costs, lead product, slime treatment, analytical methods and bibliography; three appendices describe the parent plant at Trail, the newer plant at Graselli, and the newer methods of slime treatment. The reviewer has arranged these chapters in a more logical order than they are presented in the book, where the slime treatment is described before anything else about the process. The reason for this inversion is not hard to see. Mr. Betts has had more trouble with the working up of the slimes than with anything else, and he puts it in the forefront as the chief thing in his book.

The work as a whole is a metallurgical classic as to its substance, but not as to the manner of its presentation. There is nothing to criticize as to what Mr. Betts gives us, but we could have wished that the arrangement of chapters had been more logical, the treatment of the several topics more systematic, and the English language used more carefully and discriminatingly. In other words, the book lacks somewhat in orderly arrangement and literary polish. Perhaps we should say that these are immaterial as long as the information is there—and the information *is* there—but the finishing touches spoken of as lacking would have made the book more perfect as a metallurgical classic.

We cannot help discoursing on the vast difference between a broad-minded scientist who writes a book like this and a narrow-minded, money-making technologist who never writes a line or says a word about his own work in metallurgy or chemistry, and whose whole aim in life seems to be to get rich by keeping as much information as possible away from his fellow chemists. Such there are, connected with powerful commercial organizations, the fruits of whose labors are entirely absorbed by and inuring to the benefit of their money-grasping employers. Science, their foster-mother, gives them everything, and they return not an iota. They are leeches on the body scientific who share her life blood and contribute not one mite of sustenance to her in return. May they see Mr. Betts' altruistic contribution to science and industry and be forthwith ashamed of themselves and go and do likewise as far as it is in their power to do.

* * * *

Absorption of Vapors and Gases by Soils. By Harrison E. Patten and Francis E. Gallagher. (With a preface by Frank K. Cameron.) 50 pages, 90 illustrations. Washington: United States Department of Agriculture (Bureau of Soils, Bulletin 51).

The work described in this bulletin marks the conclusion of an interesting series of studies of absorption carried out by the Bureau of Soils and relating to subjects of great scientific interest, and at the same time of practical applicability in agriculture.

"The relation between the absorption of water vapor, on the one hand, and the evaporation of water from soil has been carefully investigated, and the laws controlling it have been clearly brought out, and the influence of soluble materials contained in the soil as affecting these laws has been shown. The significance of cultural methods as affecting either the absorption of water vapor or its evaporation has been shown. And finally, the important practical fact has been established that the wilting point—or that water content of the soil at which plants can no longer thrive and which has been shown elsewhere to be a physical factor of the soil—marks a water content higher than that which the soil can attain by direct absorption from a humid atmosphere, even though this latter be maintained at the point of saturation.

"The laws governing the absorption of other gases or vapors appear in general to be very similar to those governing the absorption of water vapor, and it may now be safely claimed that the broad subject of absorption of vapors by soils has been brought to a satisfactory state as regards not only our theoretical knowledge of the principles involved and their importance to practical agriculture, but also as they bear upon the practical methods of control."

* * * *

A Text-Book of Organic Chemistry. By A. F. Holleman, Ph.D., professor in the University of Amsterdam. Translated from the third Dutch edition by A. Jamieson Walker, Ph.D., and Owen E. Mott, Ph.D., with the co-operation of the author. Second English edition, rewritten. 589 pages, 80 illustrations. Bound in cloth. Price, $2.50. New York: John Wiley & Sons.

The first English edition, which had been prepared from the second Dutch edition and was reviewed on page 430 of our first volume, has met with a demand so great as to exceed anticipation. It has been necessary to print a short edition from the existing plates during the revision of the text for the present second edition.

This second edition has been entirely rewritten. While it is based on the third Dutch edition of Holleman's "Leerboek der Organische Chemie," the progress of the science has necessitated numerous and extensive alterations. The book is, therefore, fully up-to-date.

Without going into details, we may repeat what we said in our former review of the general character of the work. "The Holleman book is not a descriptive or encyclopædic handbook. It is a text-book, in which the theory is presented with just sufficient description of organic compounds, to illustrate the classification. From this point of view it is an excellent work and full of suggestion."

* * * *

Journal of American Peat Society. Vol. I, No. 1, April, 1908. Published quarterly by the American Peat Society. Subscription price, $2 per volume of four numbers. Single numbers, 50 cents. St. Clair Building, Toledo, Ohio.

On the industrial importance of the peat problem and on the formation of the American Peat Society, we commented editorially in our October issue last year. The first number of the *Journal* of this new society has just been issued. It is an octavo pamphlet of 22 pages and contains the following articles: C. A. Davis on the peat industry and its possibilities in America; O. K. Zwingenberger, sime suggestions on peat machines; H. M. Wilson on swamp lands and their reclamation; W. G. Milne on peat as a steam fuel, and Julius Bordollo on a peat celebration.

We sincerely hope that this new journal and the society which is the sponsor for it will meet with success in their endeavor to bring the problems of the utilization of peat deposits nearer to practical solution.